Exhibit A

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Counsel for Defendants Xactware Solutions, Inc. and Verisk Analytics, Inc.

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW JERSEY

EAGLE VIEW TECHNOLOGIES, INC. and PICTOMETRY INTERNATIONAL CORP.,

Plaintiffs,

v.

XACTWARE SOLUTIONS, INC. and VERISK ANALYTICS, INC.,

Defendants.

Civil Action No. 15-cv-07025-RBK-JS

DEFENDANTS' REVISED INVALIDITY CONTENTIONS PURSUANT TO L. PAT. R. 3.3 AND 3.7

b. Whether Each Item of Prior Art Anticipates Each Asserted Claim or Renders it Obvious (L. Pat. R. 3.3(b))

As set forth above, in addition to the disclosures and arguments set forth in these contentions, Defendants adopt and incorporate by reference the disclosures and arguments set forth in the February 8 IPRs, the subsequent IPRs, and in the materials filed in support of their motion to dismiss (D.E. 50).

i. The '436 Patent

The Asserted Claims of the '436 Patent are obvious. Specifically, as further described below and in the attached claim charts, claims 1-2, 5, 8, 18, 21, 36, and 37 of the '436 Patent are invalid in light of at least the following reasons:

Claims 1-2, 5, 8, 18, 21, 36, and 37 of the '436 Patent are:

- Obvious over Hsieh either alone or in view of Applicad and/or Aerowest
- Obvious over Noronha either alone or in view of Applicad and/or Aerowest
- Obvious over Labe either alone or in view of Applicad and/or Aerowest
- Obvious over McKeown either alone or in view of Applicad and/or Aerowest
- Obvious over Avrahami either alone or in view of Applicad and/or Aerowest

- Obvious over Sungevity either alone or in view of Applicad and/or Aerowest

Claims 1-2, 5, 8, 18, 21, 36, and 37 of the '436 Patent

All of the asserted claims of the '436 Patent are obvious.

Hsieh discloses an automated and semi-automated site modeling system that can model roofs having a plurality of planar roof sections using one or more aerial images. *See*, *e.g.*, Hsieh, Abstract. More specifically, the system provides the ability to construct and manipulate three-dimensional building models using multiple images. *See, e.g.*, Hsieh, Abstract and p. 1. The semi-automated site modeling system can require user input to supply the automated processes. *See, e.g.*, Hsieh, p. 1. In Hsieh, the system can detect peak roof building models, which require at least two roof planes. *See, e.g.*, Hsieh, p. 6. To model roofs in Hsieh the user measures the roof of a building in one aerial image by outlining the roof in that aerial image. *See also* Hsieh, p. 20. The system then detects peaks, edges, and other roof features in the image, and generates a full three-dimensional (3D) model of the building (including the roof). *See also* Hsieh, p. 20. The system also projects the 3D model onto other aerial images of the building. *See, e.g.*, Hsieh, pp. 6, 29.

In Hsieh, the building measurement process is broken down into a verification component, an object matching component, and an edge estimation

Additionally, all of the asserted claims of the '436 Patent are obvious over Sungevity in view of Applicad and/or Aerowest.

Sungevity is prior art to the '436 Patent for at least the following reasons. Sungevity is entitled to a priority date of February 1, 2008. The claims of the '436 Patent are not fully supported by provisional application no. 60/925,072 (filed on April 17, 2007), and accordingly, are not entitled to the benefit of the filing date of the '072 provisional application. Furthermore, the '436 Patent does not claim priority to any other application that predates the February 1, 2008 priority date of Sungevity. (*See* 9/4/12 Amendments and Remarks; 10/18/12 Amendments and Remarks; and 12/12/12 Notice of Allowance and Fees Due for U.S. Patent Application No. 12/364,506). Defendants deny that the '436 Patent is entitled to claim priority to any application that pre-dates the actual filing date of the application that led to the '436 Patent.

Sungevity enables a user interested in installing an energy system (such as solar panels) to undertake efficient, cost effective and accurate estimation of roof properties without the need for visits to the site. Sungevity 4:19-30. For example, Sungevity provides a tool for measuring a user selected roof or other user-selected other installation surface. *Id.* Sungevity provides a sizing system for determining solar photovoltaic (PV) potential of a user selected installation site. *Id.* Sungevity further matches a user selected roof space and energy needs to commercially

produced within the following bates-numbered ranges: XW00000001 – XW00020502. As previously mentioned, Defendants have provided and will provide Plaintiffs with access to source code regarding the Accused Instrumentalities in accordance with the parties' agreement reflected in the discovery confidentiality order. [*See* D.E. 48]. Please refer to Defendants' Non-Infringement Contentions and Responses Pursuant to L. Pat. R. 3.2A for more information.

Prior art identified pursuant to L. Pat. R. 3.3(a) and 3.4(b) which does not appear in the file history of the Asserted Patents has been or is being produced.

Dated: May 3, 2017

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Counsel for Defendants Xactware

Exhibit D

U 7655045

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

October 31, 2017

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF:

U.S. PATENT: ***8,078,436***
ISSUE DATE: ***December 13, 2011***

By Authority of the
Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office

M. Tarver

M. TARVER
Certifying Officer

UNITED STATES PATENT AND TRADEMARK OFFICE DEPARTMENT OF COMMERCE

US008078436B2

(12) **United States Patent**
Pershing et al.

(10) **Patent No.: US 8,078,436 B2**
(45) **Date of Patent: Dec. 13, 2011**

(54) **AERIAL ROOF ESTIMATION SYSTEMS AND METHODS**

(75) Inventors: **Chris Pershing**, Bellevue, WA (US); **David P. Carlson**, Woodinville, WA (US)

(73) Assignee: **Eagle View Technologies, Inc.**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 532 days.

(21) Appl. No.: **12/253,092**

(22) Filed: **Oct. 16, 2008**

(65) **Prior Publication Data**

US 2009/0132436 A1 May 21, 2009

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/148,439, filed on Apr. 17, 2008.

(60) Provisional application No. 60/925,072, filed on Apr. 17, 2007.

(51) **Int. Cl.**
G06F 7/60 (2006.01)
G06F 17/10 (2006.01)

(52) **U.S. Cl.** **703/2**

(58) **Field of Classification Search** 703/2; 705/306, 705/313, 4

See application file for complete search history.

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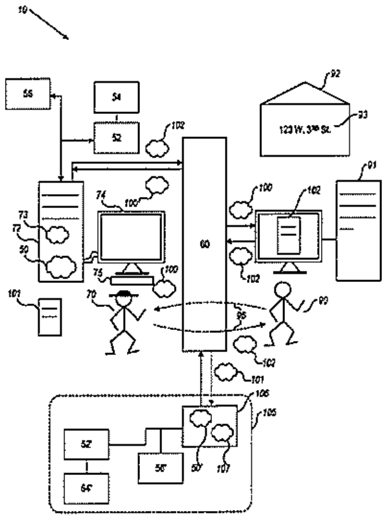
(Continued)

Primary Examiner — Dwin M Craig
Assistant Examiner — Bernard E Cothran
(74) *Attorney, Agent, or Firm* — Seed IP Law Group PLLC

(57) **ABSTRACT**

Methods and systems for roof estimation are described. Example embodiments include a roof estimation system, which generates and provides roof estimate reports annotated with indications of the size, geometry, pitch and/or orientation of the roof sections of a building. Generating a roof estimate report may be based on one or more aerial images of a building. In some embodiments, generating a roof estimate report of a specified building roof may include generating a three-dimensional model of the roof, and generating a report that includes one or more views of the three-dimensional model, the views annotated with indications of the dimensions, area, and/or slope of sections of the roof. This abstract is provided to comply with rules requiring an abstract, and it is submitted with the intention that it will not be used to interpret or limit the scope or meaning of the claims.

56 Claims, 13 Drawing Sheets



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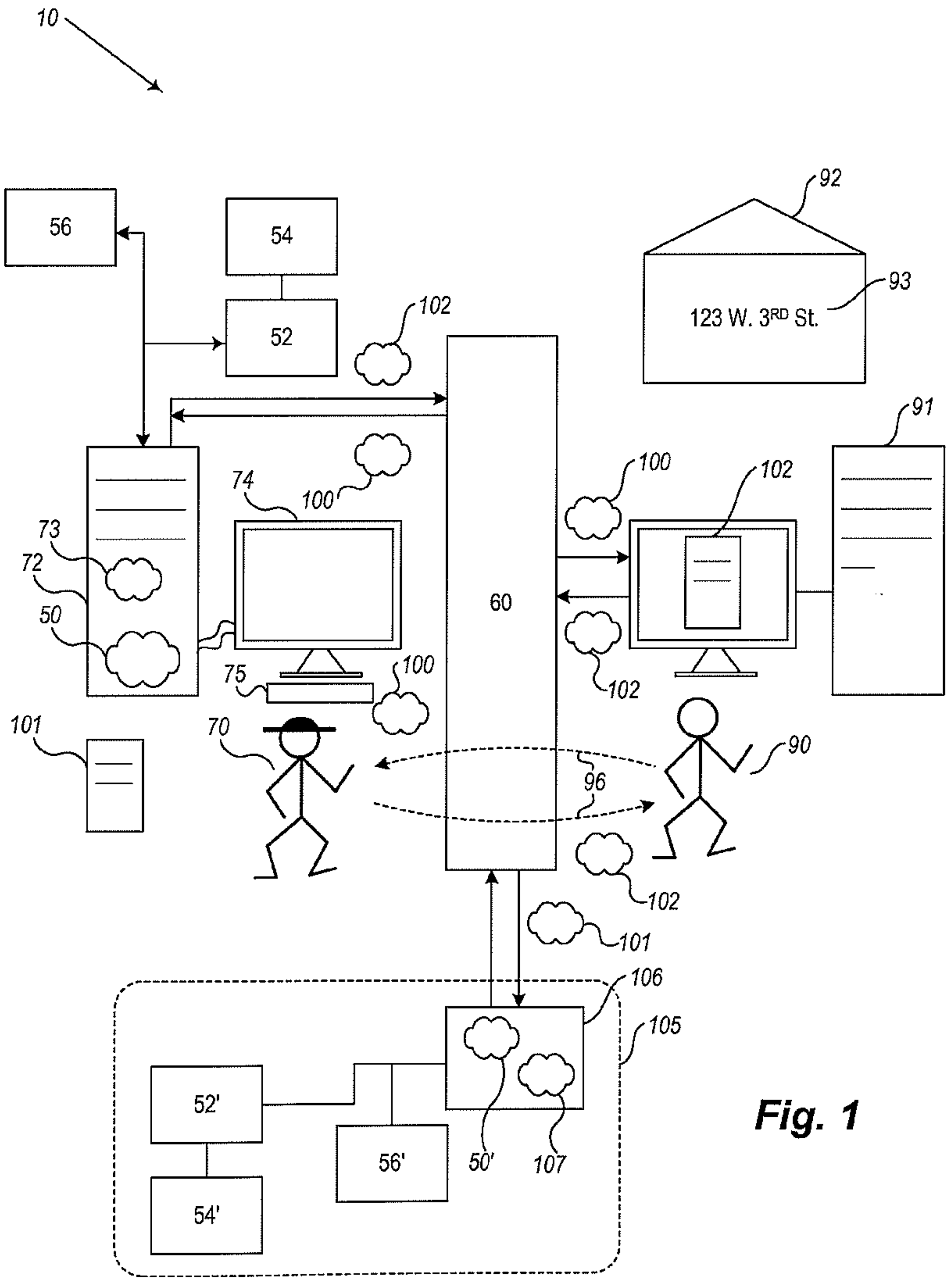
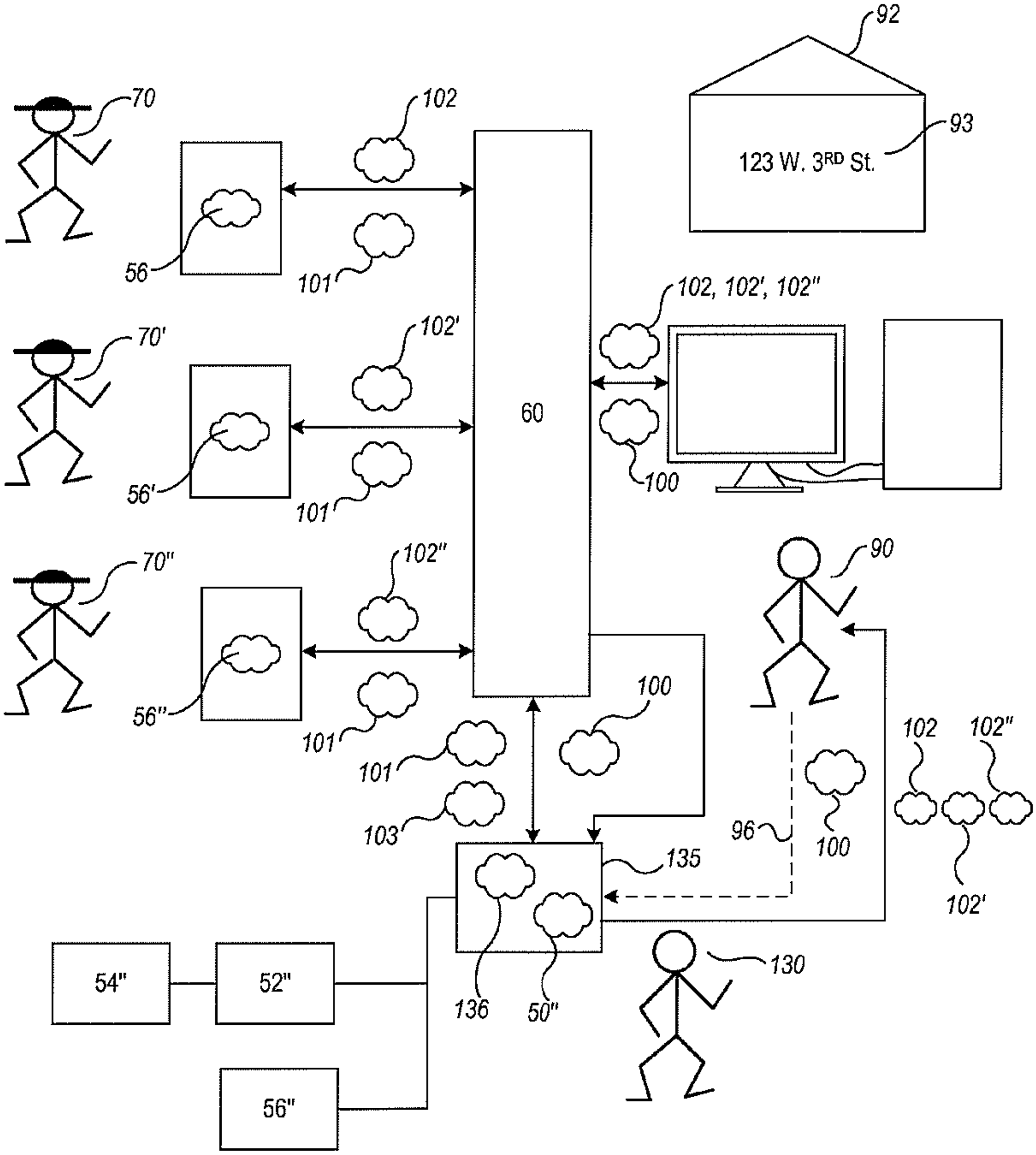

10
56
54
52
102
92
93
123 W. 3RD St.
91
60
74
100
73
72
50
75
100
102
101
70
96
90
102
101
106
105
52'
54'
56'
50'
107

Fig. 1



70
102
92
93
123 W. 3RD St.
56
101
70'
102'
102, 102', 102"
60
56'
101
100
70"
102"
90
56"
101
100
101
102
102"
103
96
100
135
102'
54"
52"
130
136
50"
56"

Fig. 2

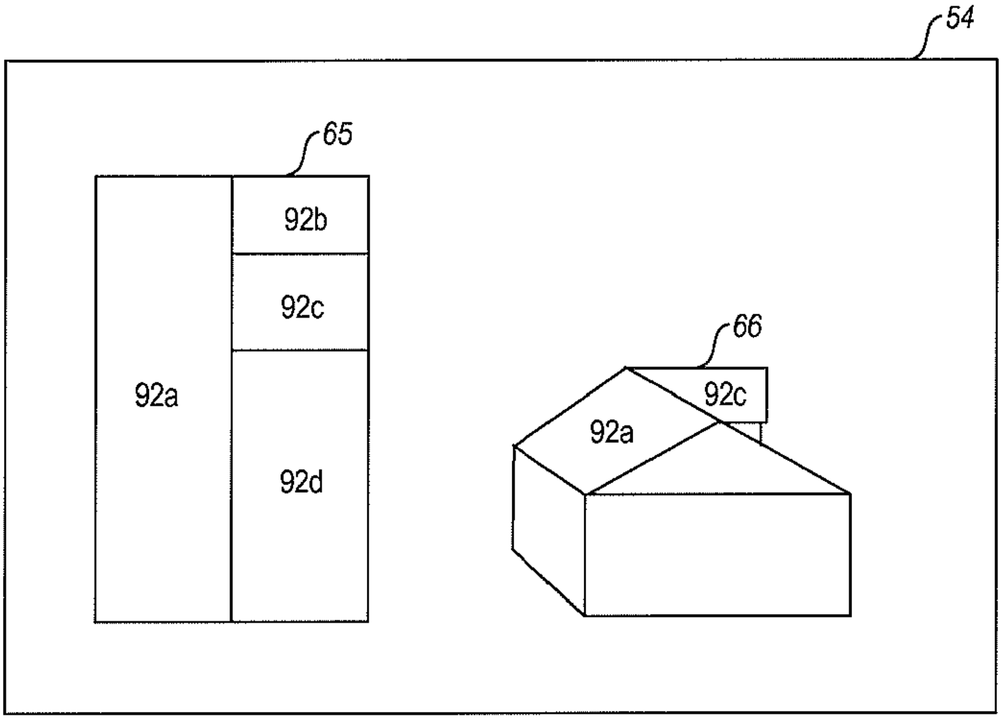


Fig. 3

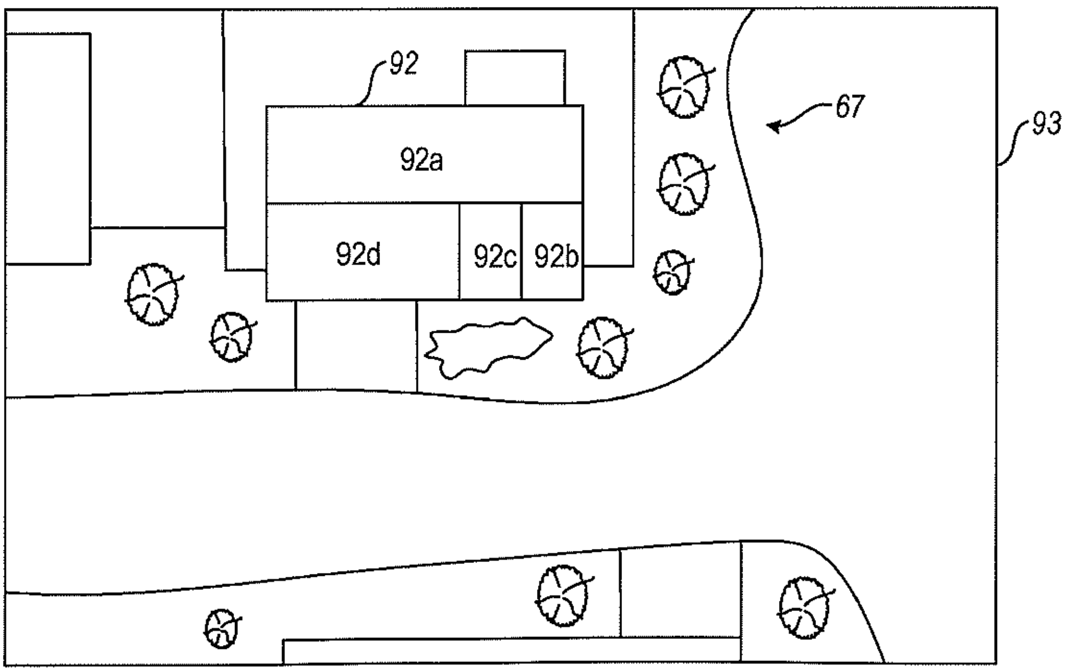


Fig. 4

1234 Main Street, Redmond, WA

Order: 2468

<Customer Name Here>

4/16/2008

103a

1234 Main Street, Redmond, WA

103b

Order: 2468 Copyright (c) 2008 Eagle View Technologies, Inc. Page 1 of 6

103

Fig. 5A

1234 Main Street, Redmond, WA

Images:

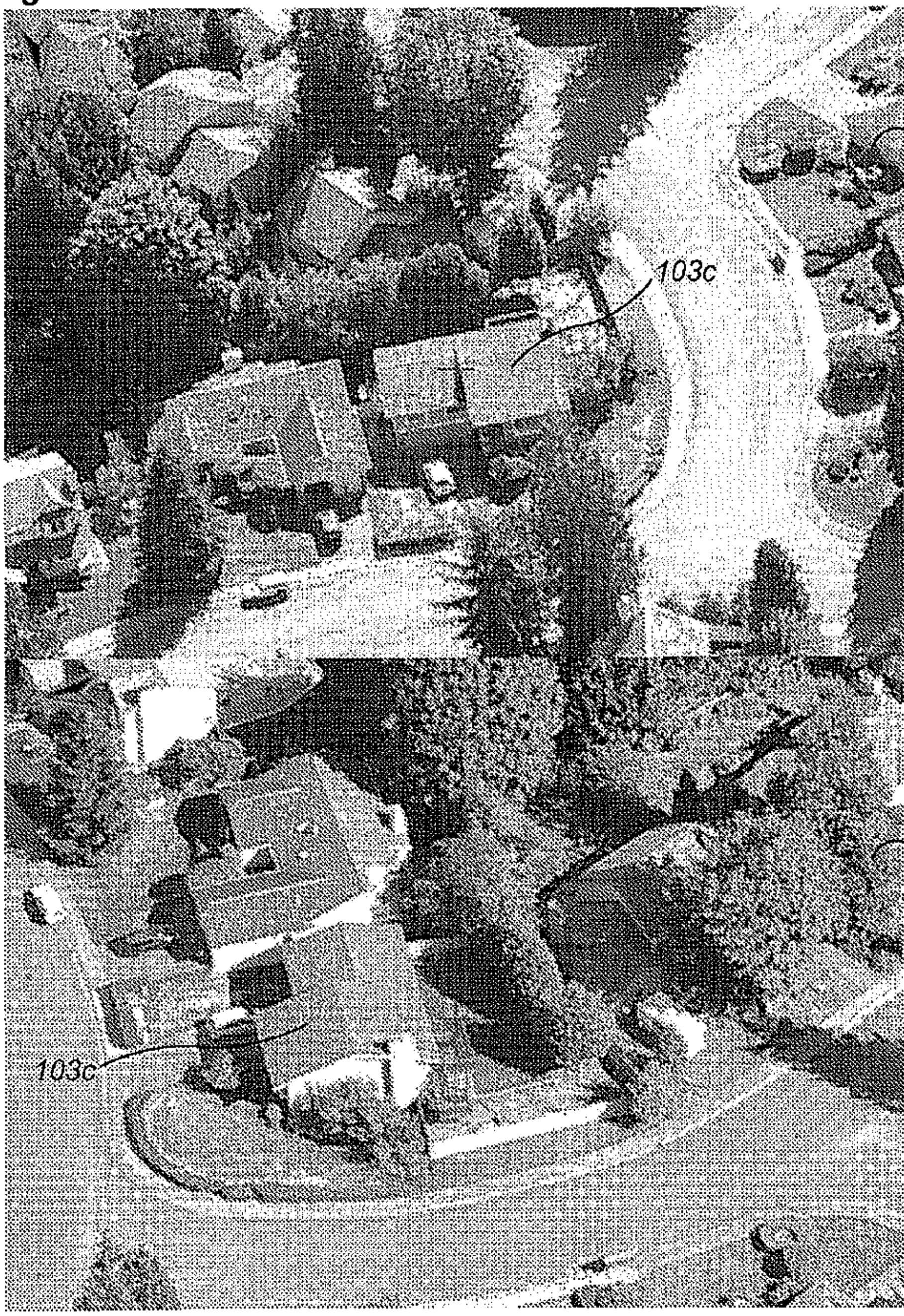


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Fig. 5B

1234 Main Street, Redmond, WA

Length Diagram:
All measurements are rounded to the nearest foot
Ridge Length = 55 ft [Red Lines]
Valley Length = 0 ft [Blue lines]

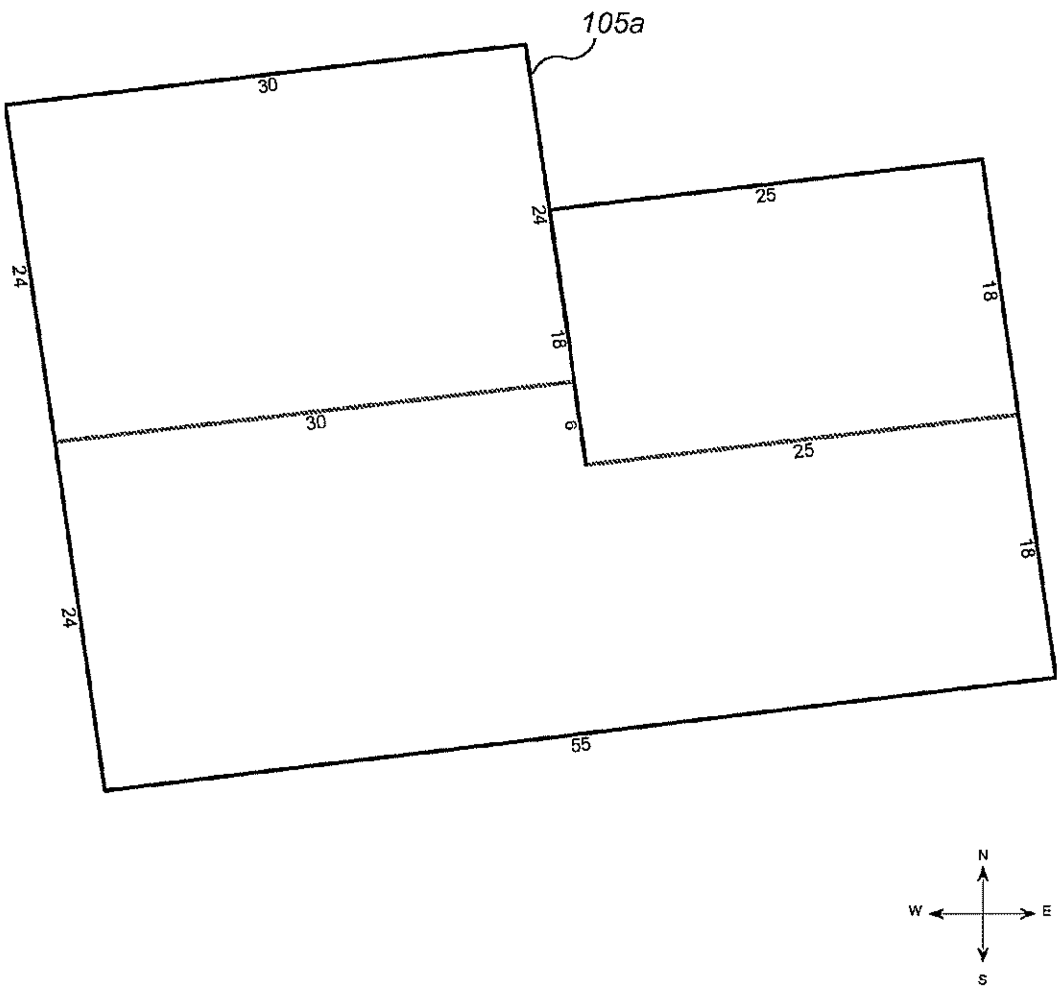

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Fig. 5C

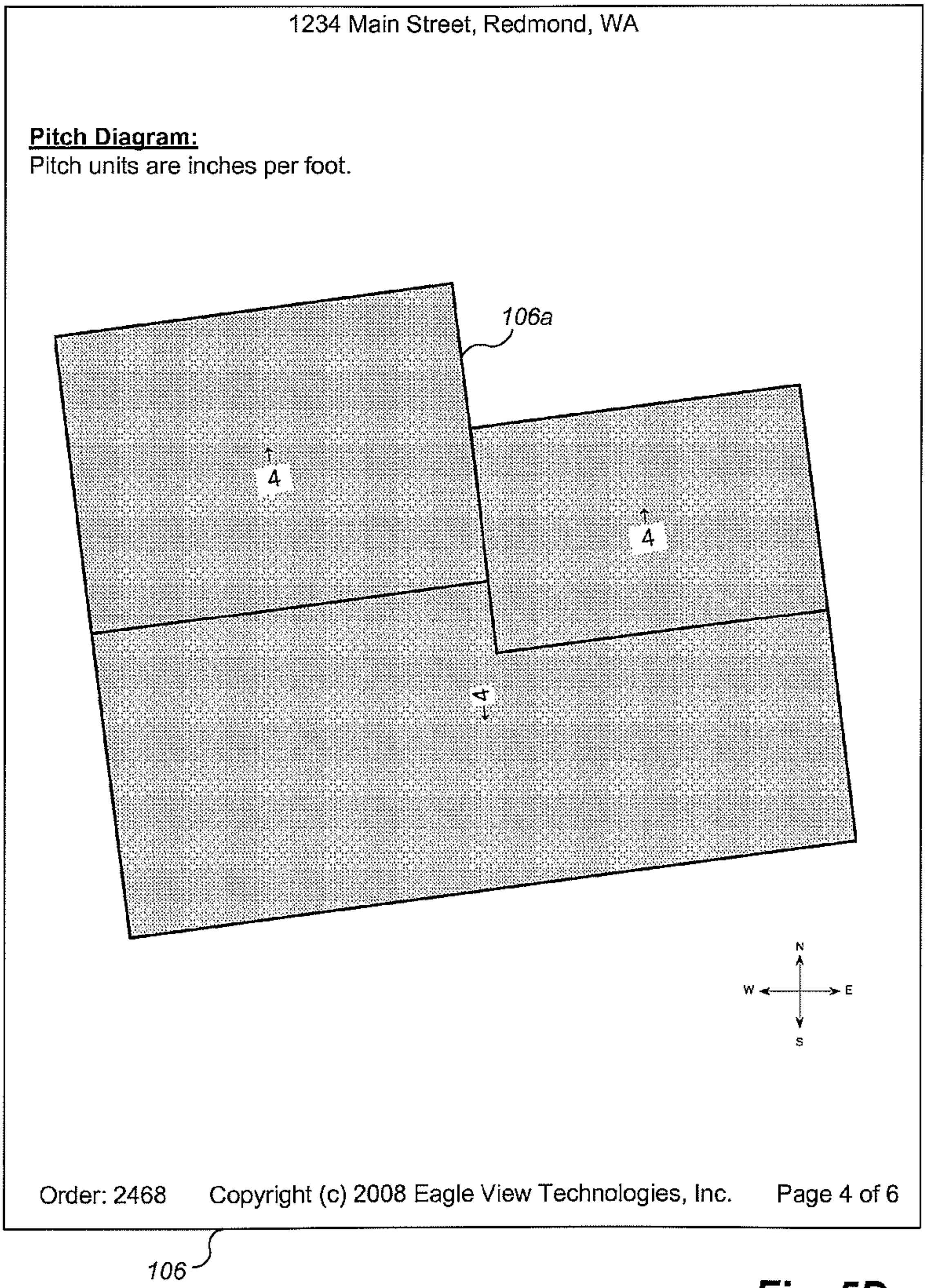

1234 Main Street, Redmond, WA
Pitch Diagram:
Pitch units are inches per foot.
106a
4
4
4
N
W
E
S
Order: 2468
Copyright (c) 2008 Eagle View Technologies, Inc.
Page 4 of 6
106

Fig. 5D

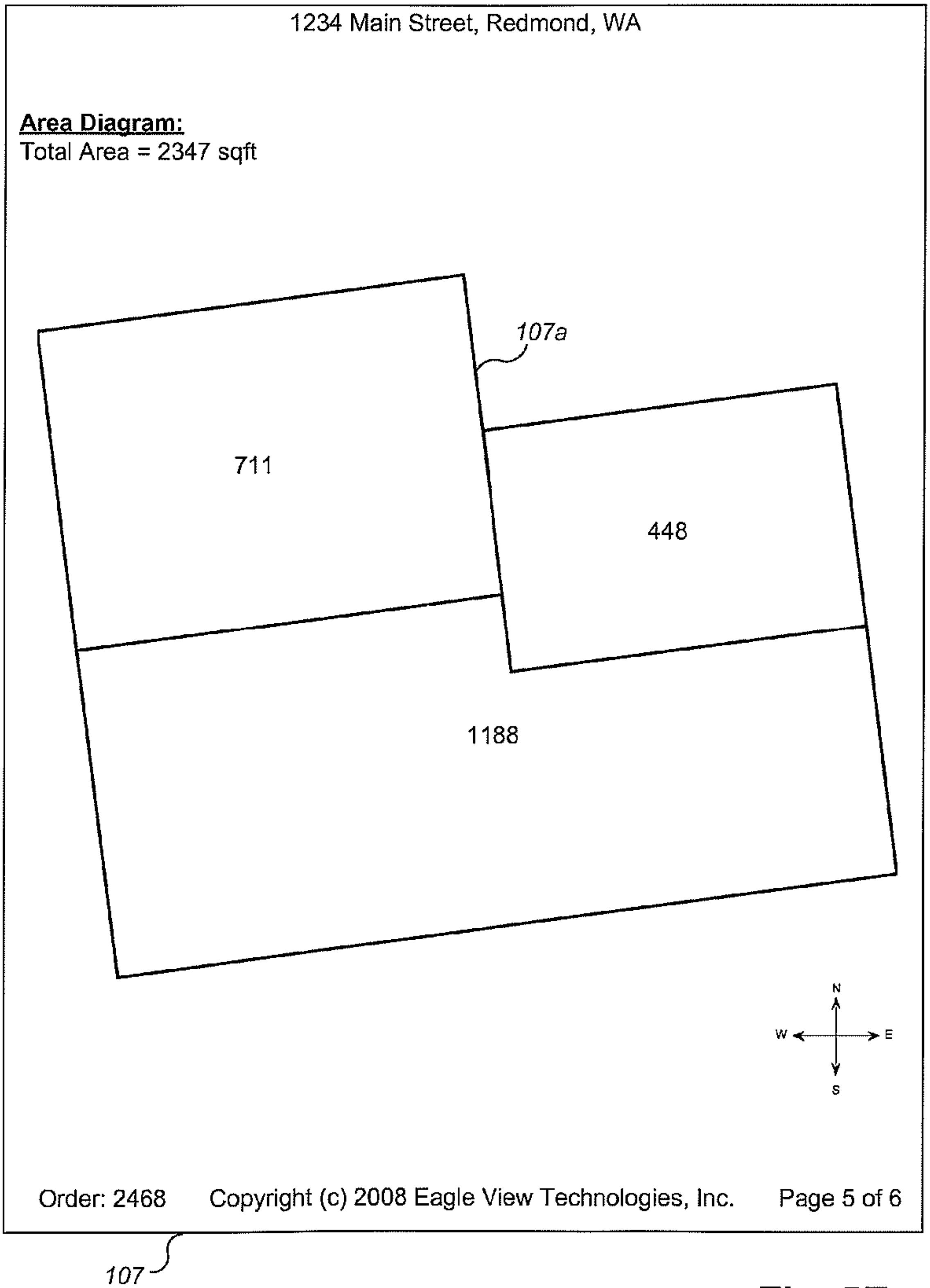

1234 Main Street, Redmond, WA
Area Diagram:
Total Area = 2347 sqft
107a
711
448
1188
N
W
E
S
Order: 2468
Copyright (c) 2008 Eagle View Technologies, Inc.
Page 5 of 6
107

Fig. 5E

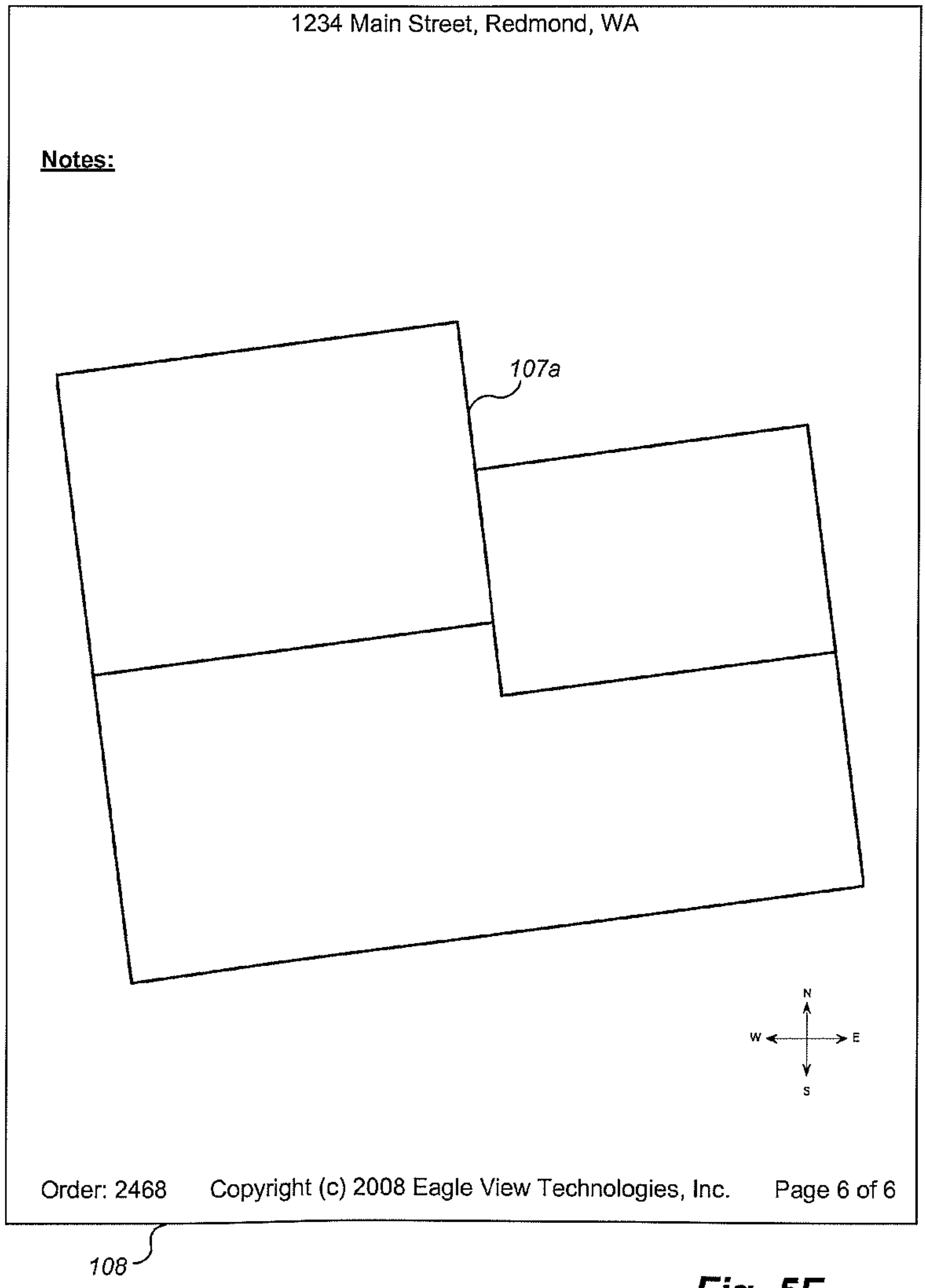
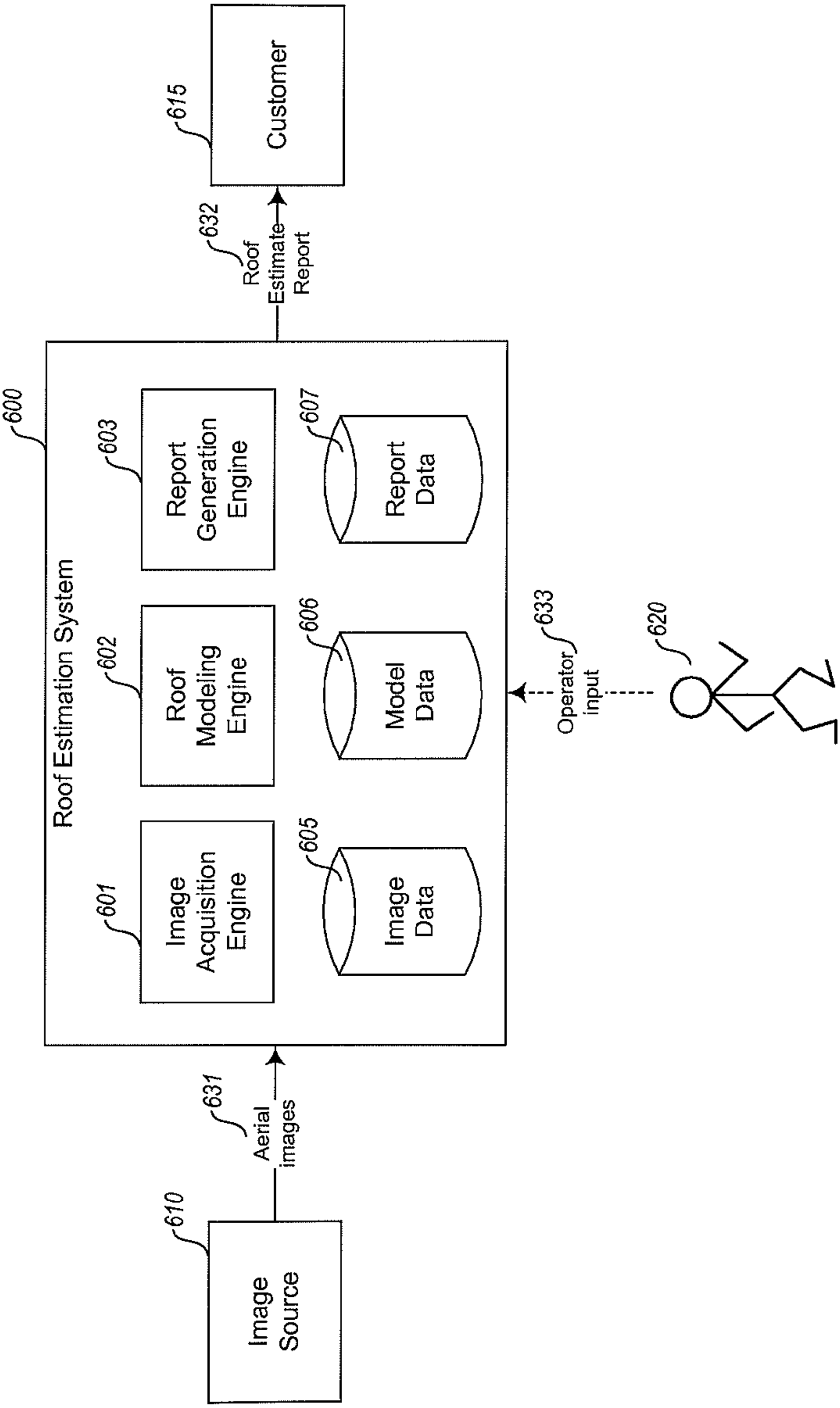
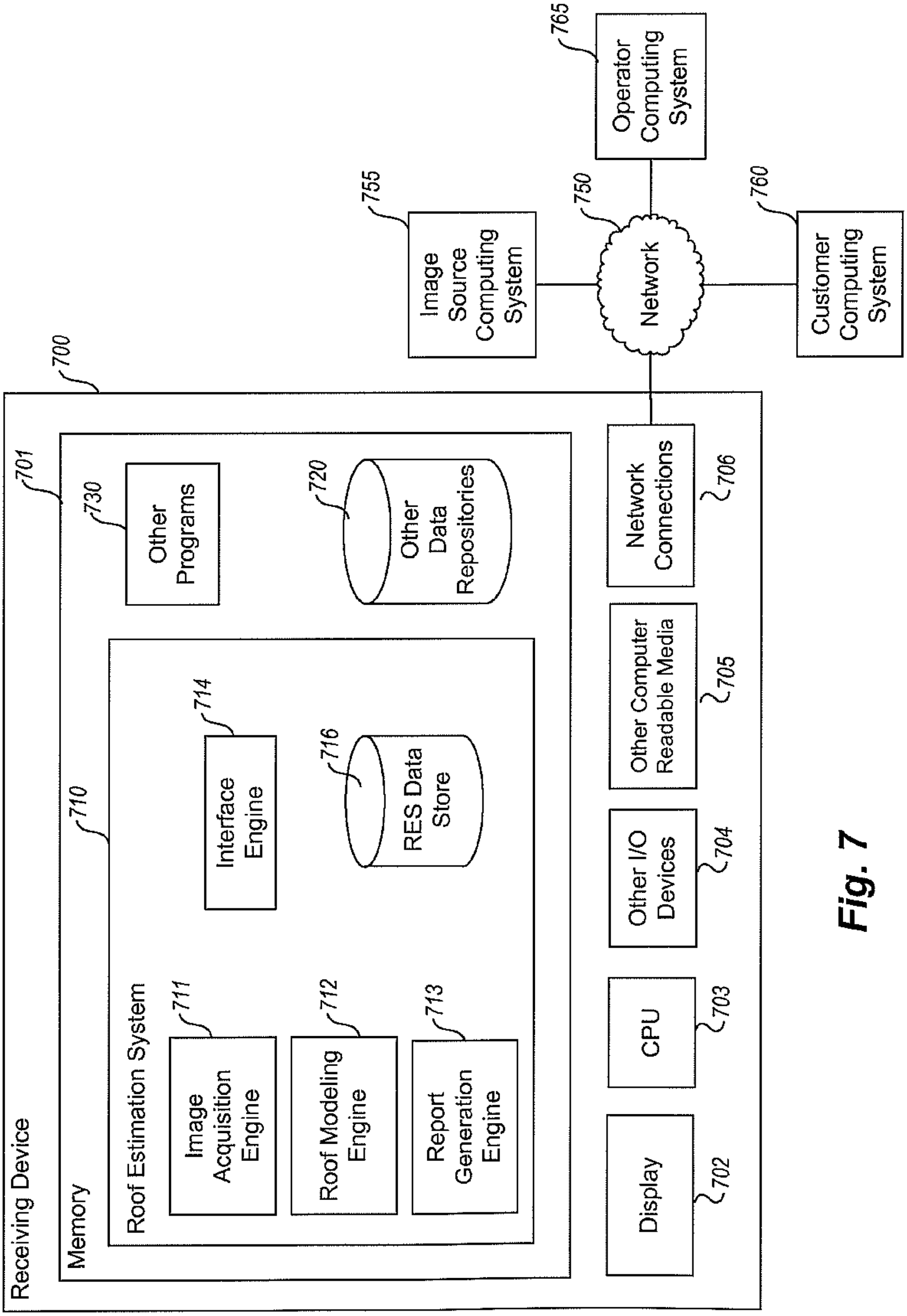

1234 Main Street, Redmond, WA
Notes:
107a
N
W
E
S
Order: 2468
Copyright (c) 2008 Eagle View Technologies, Inc.
Page 6 of 6
108

Fig. 5F

Fig. 6



615
Customer
632
Roof Estimate Report
600
Roof Estimation System
603
Report Generation Engine
602
Roof Modeling Engine
601
Image Acquisition Engine
607
Report Data
606
Model Data
605
Image Data
633
Operator input
620
631
Aerial images
610
Image Source



765
Operator Computing System
755
Image Source Computing System
750
Network
760
Customer Computing System
700
Receiving Device
701
Memory
730
Other Programs
720
Other Data Repositories
710
Roof Estimation System
714
Interface Engine
716
RES Data Store
711
Image Acquisition Engine
712
Roof Modeling Engine
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Report Generation Engine
Network Connections
706
Other Computer Readable Media
705
Other I/O Devices
704
CPU
703
Display
702

Fig. 7

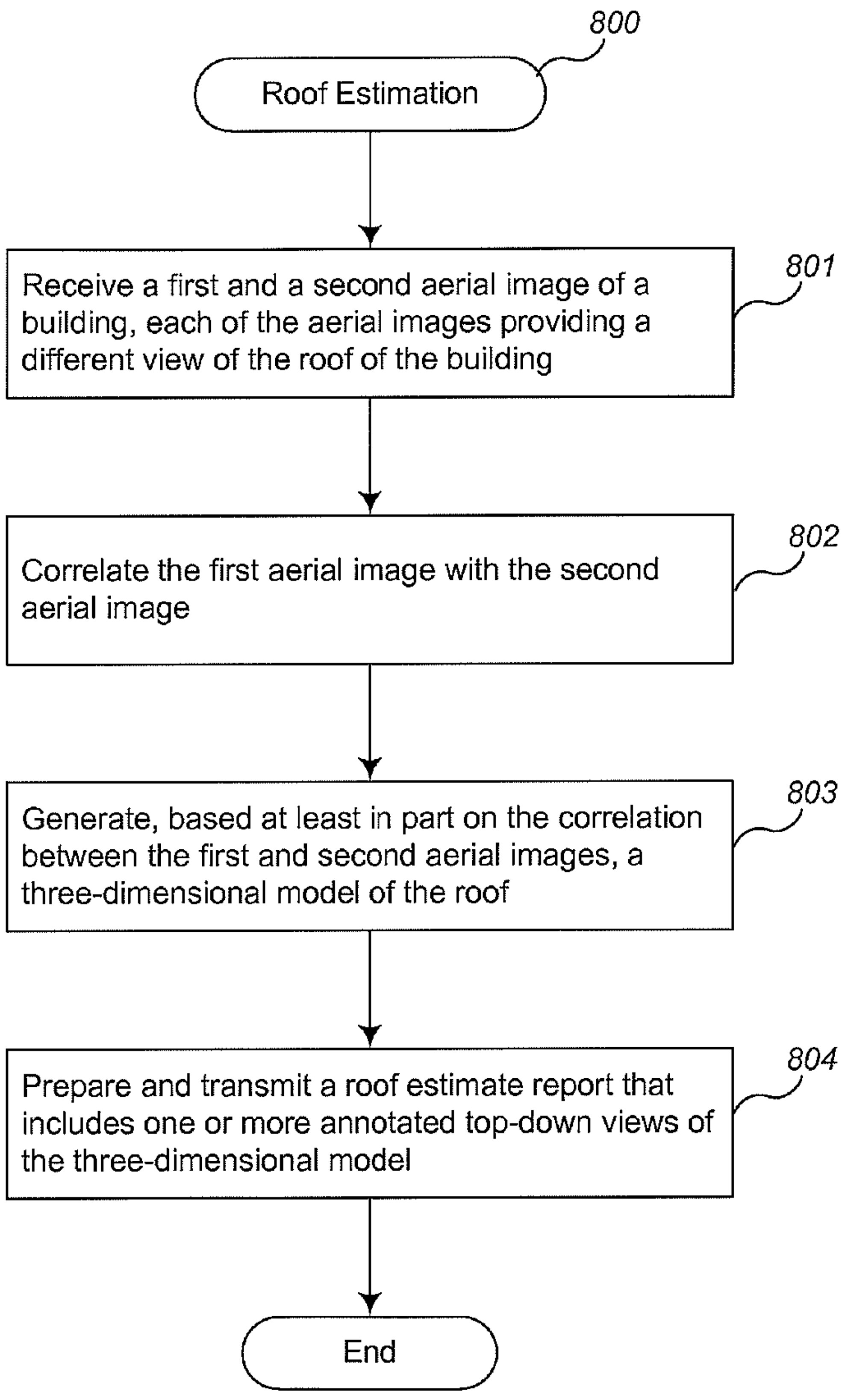
800
Roof Estimation
801
Receive a first and a second aerial image of a building, each of the aerial images providing a different view of the roof of the building
802
Correlate the first aerial image with the second aerial image
803
Generate, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof
804
Prepare and transmit a roof estimate report that includes one or more annotated top-down views of the three-dimensional model
End

Fig. 8

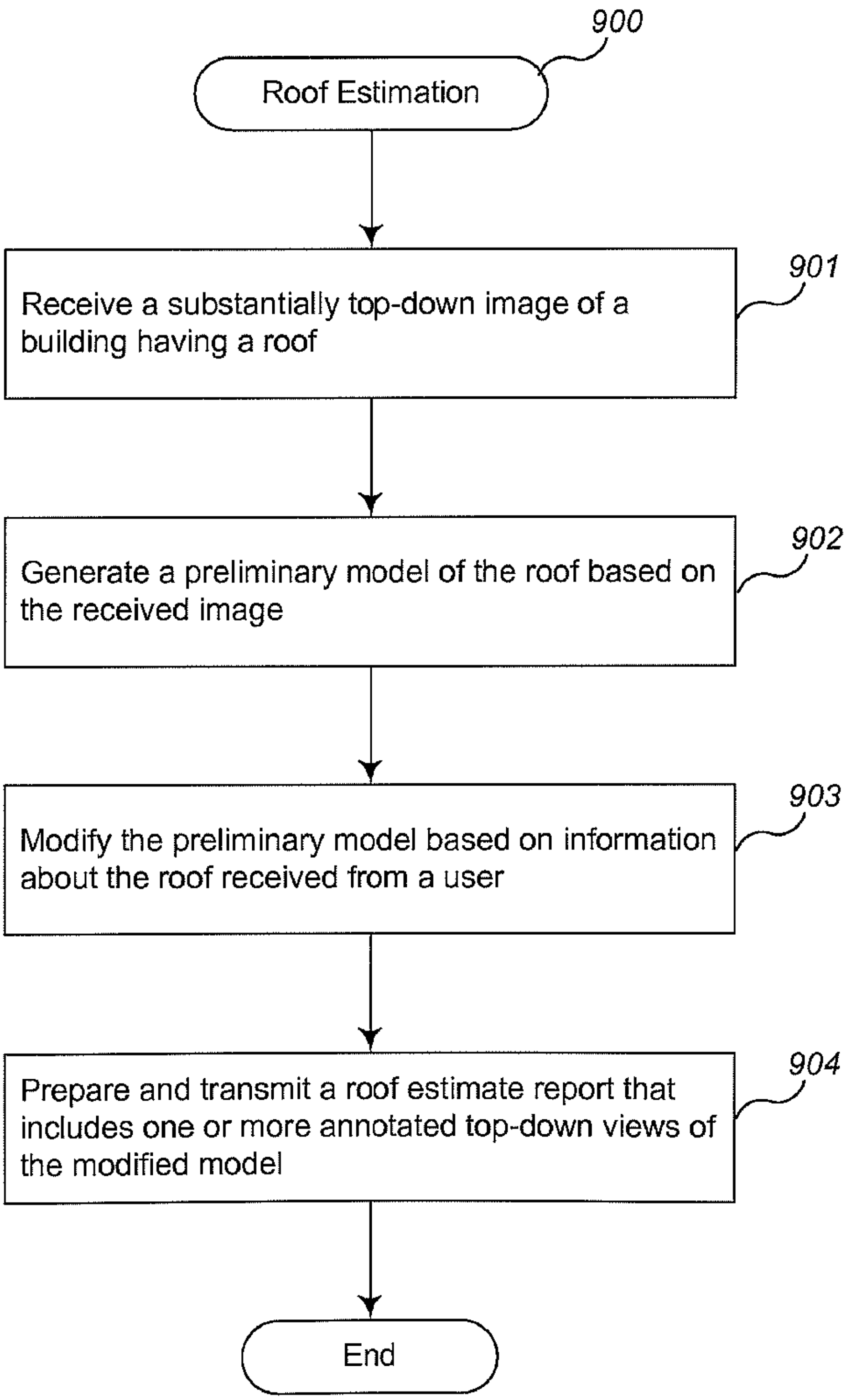
900
Roof Estimation
901
Receive a substantially top-down image of a building having a roof
902
Generate a preliminary model of the roof based on the received image
903
Modify the preliminary model based on information about the roof received from a user
904
Prepare and transmit a roof estimate report that includes one or more annotated top-down views of the modified model
End

Fig. 9

AERIAL ROOF ESTIMATION SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 12/148,439, filed on Apr. 17, 2008, which claims the benefit of U.S. Provisional Patent Application No. 60/925,072, filed on Apr. 17, 2007, each of which are incorporated herein by reference in their entireties.

BACKGROUND

1. Field of the Invention

This invention relates to systems and methods for estimating construction projects, and more particularly, to such systems and methods that allow estimates involving roofs on buildings to be created remotely.

2. Description of the Related Art

The information provided below is not admitted to be part of the present invention, but is provided solely to assist the understanding of the reader.

Homeowners typically ask several roofing contractors to provide written estimates to repair or replace a roof on a house. Heretofore, the homeowners would make an appointment with each roofing contractor to visit the house to determine the style of roof, take measurements, and to inspect the area around the house for access and cleanup. Using this information, the roofing contractor then prepares a written estimate and then timely delivers it to the homeowner. After receiving several estimates from different rooting contractors, the homeowner then selects one.

There are factors that impact a roofing contractor's ability to provide a timely written estimate. One factor is the size of the roof contractor's company and the location of the roofing jobs currently underway. Most roof contractors provide roofing services and estimates to building owners over a large geographical area. Larger roof contractor companies hire one or more trained individuals who travel throughout the entire area providing written estimates. With smaller roofing contractors, the owner or a key trained person is appointed to provide estimates. With both types of companies, roofing estimates are normally scheduled for buildings located in the same area on a particular day. If an estimate is needed suddenly at a distant location, the time for travel and the cost of commuting can be prohibitive. If the roofing contractor is a small company, the removal of the owner or key person on a current job site can be time prohibitive.

Another factor that may impact the roofing contractor's ability to provide a written estimate is weather and traffic.

Recently, solar panels have become popular. In order to install solar panels, the roof's slope, geometrical shape, and size as well as its orientation with respect to the sun all must be determined in order to provide an estimate of the number and type of solar panels required. Unfortunately, not all roofs on a building are proper size, geometrical shape, or orientation for use with solar panels.

SUMMARY

These and other objects are met by the system and method disclosed herein that allows a company that needs the sizes, dimensions, slopes and orientations of the roof sections on a building in order to provide a written estimate. A roof estimation system ("RES") that practices at least some of the techniques described herein may include a roof estimating software program and a location-linked, image file database. During use, the physical address or location information of a building is provided to the program, which then presents aerial images of roof sections on the building at the specific address location. An overhead aircraft, a balloon, or satellite may produce the aerial images. An image analysis and calibration is then performed either manually and/or via a software program that determines the geometry, the slopes, the pitch angles, and the outside dimensions of the roof sections. The images may also include the land surrounding the roof sections and building which the estimating company can use to factor in additional access or clean-up costs.

In a first embodiment of the roof estimation system, a roof estimation service is contacted by a potential customer requesting an estimate for repair or replacement of a roof on a building. The roof estimation service uses a local computer with an estimating software program loaded into its working memory to access an image file database located on the computer or on a remote server connected via a wide area network to the local computer. The image file database contains image files of various buildings. When a request for an estimate is received from a potential customer, the roof estimation service enters the customer's address into the software program and aerial images of the building are then presented to the roof estimation service. The roof estimation service then manually measures or uses a roof estimation software program to determine the slopes, dimensions, and other relevant geometric information of the roof sections on the buildings. From these determinations, the overall shape, slopes and square footage of the roof sections are determined and a report is produced. After the report has been prepared, the images are reviewed again for special access and cleanup tasks which can be added to the final estimate before transmission to the potential customer.

In another embodiment, the roof estimate software program and image file database, operated by a roof estimation service, are both stored on one or more a remote computers and accessed by a roof company, via a wide area network. The roof company uses an assigned user name and password to log onto the Web site and accessed the computer. After logging on, the roof company submits an address of a building, other relevant job related information, and a request for a report from the roof estimation service. The roof estimation service associated with the Web site uses the address information to obtain the images of the roof sections on the building(s) and uses the roof estimation software program and calibration module to determine the relevant geometry, pitch angles, dimensions, and surface areas of the building's roof. The roof estimation service then produces and sends a report to the roof company. The roof company then uses the report to prepare a final estimate that is then delivered to its potential customer.

In another embodiment, a roof estimating Web site is created designed to receive requests for roof estimates directly from potential customers in a region. The roof estimation service that operates the Web site is associated with various roof companies that provide roof-related services in the region serviced by the Web site. When a potential customer contacts the Web site and requests an estimate for a roof repair, replacement or installation of equipment, the potential's customer's name, address, and contact information is first submitted on the Web site. The estimation service representative enters the address of the building into the roof estimation software program. The aerial images of the buildings are then obtained and analyzed by the service representative to extract the relevant geometric information about the structures. A report containing the geometric information obtained

from the aerial images and other relevant project related information supplied by the potential customer are transmitted to roof companies associated with the estimation service. The roof company reviews the information then prepares an estimate which then can be uploaded to the roof estimating Web site server which then forwards the estimate to the potential customer, or sent from the roof company directly via email, fax or mail to the potential customer.

In another embodiment, a roof estimation service associated with the roof estimate Web site uses the image file database and roof estimate software to preemptively calculate and store the dimensions, areas, pitch angles, and other relevant geometric information about the buildings and structures located within a geographic region. This pre-calculated information can then be used by any of the previously mentioned embodiments to accelerate the process of obtaining roof estimates within that geographic region.

It should be understood, that the systems and methods described herein may be used by any individual or company that would find the calculation of the size, geometry, pitch and orientation of the roof of a building from aerial images of the building useful. Such companies may include roofing companies, solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and insurance companies.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration showing embodiments of a system and method for roof estimation.

FIG. **2** is an illustration showing another embodiment of a system and method for roof estimation.

FIG. **3** is an illustration showing the top and perspective view of a house for a particular address.

FIG. **4** is an aerial image of the home shown in FIG. **3** showing the areas and structures around the home.

FIGS. 5A-5F are consecutive pages from a preliminary or final report sent to a potential customer prepared by the roofing company.

FIG. **6** is a block diagram illustrating example functional elements of one embodiment of a roof estimation system.

FIG. **7** is an example block diagram of a computing system for practicing embodiments of a roof estimation system.

FIG. **8** is an example flow diagram of a first example roof estimation routine provided by an example embodiment.

FIG. **9** is an example flow diagram of a second example roof estimation routine provided by an example embodiment.

DETAILED DESCRIPTION

Referring to the accompanying Figures, there is described a roof estimation system ("RES") **10** and method that allows a roof estimation service **70** to provide a final estimate **102** to a potential customer **90** to install equipment or to repair or replace the roof on a building **92** using aerial images of the building **92**, as shown in FIG. **1**. The roof estimation service **70** may be any service that provides roof estimates to customers. In one embodiment, the roof estimation service **70** typically provides roof estimates to customers who are roof companies or other entities involved in the construction and/or repair of roofs, such as builders, contractors, etc. In another embodiment, the roof estimation service **70** is a roof company that is directly involved in the construction and/or repair of roofs, and that provides estimates to customers that are property owners, general contractors, etc. The system **10** includes an estimating software program **50** designed to receive an address for the building **92**. The software program **50** is linked to an aerial image file database **52** that contains aerial images files **54** of various building **92** in a region. The aerial image files **54** may be taken any available means, such as a manned or unmanned aircraft, a balloon, a satellite, etc. In some embodiments, the aerial image files may include images taken from a ground-based platform, such as a mobile ("street view") photography vehicle, a fixed position (e.g., a tower, nearby building, hilltop, etc.), etc. As shown in FIG. **3**, the image files **54** typically include at least one a top plan view **65** and a perspective view **66** of the building **92**. The roof of the building **92** includes multiple planar roof sections **92***a*-**92***d*.

As shown in FIG. **4**, the image files **54** may also include a wide angle image **67** showing the building **92** and the surrounding areas **93** around the building **92**.

Referring back to FIG. **1**, in one embodiment, an image analysis and calibration module **56** is linked to the software program **50** that enables the roof estimation service **70** to closely estimate the dimensions and slopes of the roofs of the buildings **92** shown in the views **65**, **66**. By simply inputting the customer's address into the software program **50**, the roof estimation service **70** is able view the customer's roof from the aerial image files **54** using a remote computer **72**, determine the dimensions and slopes of the roof sections that make up the roof, and prepare a preliminary report **101** which is then used to prepare a final estimate **102** that is then delivered to the potential customer **90**.

FIG. **1** is an illustration showing the system **10** used by a potential customer **90** requesting a roof estimate from a roof estimation service **70** that uses the system **10** described above. The potential customer **90** may be the building tenant, owner or insurance company. The roof estimation service **70** uses a computer **72** which may connect to a wide area network **60**. The customer **90** contacts the roof estimation service **70** via his or her computer **91** and the wide area network **60** or by a telecommunication network **96**, and requests a roof estimate **100** for his building **92** located at a public address **93**. (in this example, "123 W. 3rd St."). The roof estimation service **70** then processes the request **100** which leads to a final estimate **102** being delivered to the potential customer's computer **91** or via email, fax or postal service to the potential customer **90**.

There are several different ways the system **10** can be setup. FIG. **1** shows a first embodiment of the system **10** where the roof estimation service **70** operates a remote computer **72** with a display **74** and a keyboard **75** or similar input means, such as a mouse, joystick, track pad, etc. A roof estimating software program **50** is loaded into the working memory **73** of the remote computer **72**. The software program **50** is able to retrieve aerial images of buildings from the database **52** containing aerial images files **54** of buildings located in the region served by the roof estimation service **70**. In the first embodiment shown in FIG. **1**, the remote computer **72** is linked or connected to a database **52** containing aerial images files **54** of the buildings. The software program **50** includes a calibration module **56** that enables the roof estimation service **70** to determine the angles and dimensions of various roof sections shown in the images files **54**. After the angles and dimensions are determined, the combined square footage of the building **92** can be determined which is then used to create a preliminary report **101**. The roof estimation service **70** then reviews the wide angle image file **67** (see FIG. **4**) to determine if the building **92** has special access and clean up factors that may impact the final estimate **102**. Once the preliminary report **101** or the final estimate **102** is prepared by the roof estimation service **70**, one or both can be transmitted to the customer **90** via the wide area network **60**, the telecommunication network **96**, or by postal service.

Also shown in FIG. 1 is an alternative setup of the system **10** wherein a preliminary report **101** is prepared by a separate roof estimating entity **105** which is then forwarded to the roof estimation service **70** who then prepares the final estimate **102** and sends it to the customer **90**. The entity **105** includes a computer **106** with a roof estimating software program **50'** loaded into the working memory **107**. Like the software program **50** loaded into the roof contractor's computer **72** in the previous embodiment the software program **50'** is also able to retrieve aerial images of houses from a database **52'** containing aerial images files **54'** of houses located in the region served by the roof estimation service **70**. An optional calibration module **56'** may be provided which enables the entity **105** to determine the angles and linear dimensions of various roof sections on the house **92**.

When the system **10** is set up to include the estimating entity **105**, the customer **90** may first contact the roof estimation service **70**. The roof estimation service **70** may then contact the estimating entity **105** and forward the address of the building **92** thereto. The estimating entity **105** may then prepare the preliminary report **101** that is transmitted to the roof estimation service **70**. The roof estimation service **70** may then prepare the final report **102** and send it to the customer **90**. In other embodiments, interactions between the customer **90**, the roof estimation service **70**, and the estimating entity **105** may occur in different ways and/or orders. For example, the customer **90** may contact the estimating entity **105** directly to receive a final report **102**, which the customer **90** may then forward to one or more roof companies of their choosing.

FIG. **2** shows a third embodiment of the system **10** where the customer **90** contacts a roof estimating entity **130** who receives a request **100** from the customer **90** via the wide area network **60** or telecommunication network **96**. The roof estimating entity **130** prepares a preliminary report **101** which is then transmitted to various roof estimation services **70**, **70'**, **70"** associated with the entity **130**. Accompanying the preliminary report **101** may be the name and contact telephone number(s) or email address of the customer **90**. Each roof estimation service **70**, **70'**, **70"** reviews the preliminary report **101** and any associated images sent therewith and then prepares a final estimate **102**, **102'**, **102"**. The final estimate **102**, **102'**, **102"** is then mailed, emailed or faxed to the customer **90** or back to the estimating entity **130**. The estimating entity **130** then sends the final estimate **102**, **102'**, **102"** to the customer **90**. In this embodiment, the estimating entity **130** includes a computer **135** in which the roof estimating software program **50"** is loaded into its working memory **136** loaded and linked to the aerial image database **52"** containing image files **54"**. An optional calibration module **56"** may be loaded into the working memory **136** of the computer **135**.

FIGS. **5A-5F** are individual pages that make up a representative report. In FIG. **5A**, a cover page **103** that lists the address **103*a*** of a building **103*c*** and an overhead aerial image **103*b*** of the building **103*c***. In FIG. **5B**, a second page **104** of the report is shown that shows two wide overhead perspective views **104*a*** and **104*b*** of the building **103*c*** at the address with the surrounding areas more clearly shown. FIG. **5C** is the third page **105** of the report which shows a line drawing **105*a*** of the building showing ridge and valley lines, dimensions and a compass indicator. FIG. **5D** is an illustration of the fourth page **106** of the report showing a line drawing **106*a*** of the building showing the pitch of each roof section along with a compass indicator. The pitch in this example is given in inches, and it represents the number of vertical inches that the labeled planar roof section drops over 12 inches of horizontal run. The slope can be easily calculated from such a representation using basic trigonometry. The use of a numerical value of inches of rise per foot of run is a well known measure of slope in the roofing industry. A roof builder typically uses this information to assist in the repair and/or construction of a roof. Of course, other measures and/or units of slope may be utilized as well, including percent grade, angle in degrees, etc. FIG. **5E** is an illustration of the fifth page **107** of the report showing a line drawing **107*a*** of the building showing the square footage of each roof section along with the total square foot area value. FIG. **5F** is an illustration of a sixth page **108** of the report showing a line drawing **108*a*** of the building where notes or comments may be written.

Using the above roof estimation system, a detailed description of how the system may be used in one example embodiment is now provided.

First, a property of interest is identified by a potential customer of the roof estimation service **70**. The customer may be a property owner, a roof construction/repair company, a contractor, an insurance company, a solar panel installer, etc. The customer contacts the roof estimation service with the location of the property. Typically, this will be a street address. The roof estimation service **70** may then use a geocoding provider, operated by the service **70** or some third party, to translate the location information (such as a street address) into a set of coordinates that can be used to query an aerial or satellite image database. Typically, the geo-coding provider will be used to translate the customer supplied street address into a set of longitude-latitude coordinates.

Next, the longitude-latitude coordinates of the property may be used to query an aerial and/or satellite imagery database in order to retrieve one or more images of the property of interest. It is important to note that horizontal (non-sloping) flat roofs only require a single image of the property. However, few roofs (especially those on residential buildings) are horizontally flat, and often contain one or more pitched sections. In such cases, two or more photographs are typically used in order for the service **70** to identify and measure all relevant sections and features of the roof.

Once the images of the roof section of the building are obtained, at least one of the images may be calibrated. During calibration, the distance in pixels between two points on the image is converted into a physical length. This calibration information is typically presented as a scale marker on the image itself, or as additional information supplied by the image database provider along with the requested image.

The image(s) and calibration information returned by the imagery database is entered or imported into measurement software of the service **70**.

Next, a set of reference points may be identified in each of the images. The service's **70** measurement software then uses these reference points and any acceptable algorithm to co-register the images and reconstruct the three-dimensional geometry of the object identified by the reference points. There are a variety of photo-grammetric algorithms that can be utilized to perform this reconstruction. One such algorithm used by the service **70** uses photographs taken from two or more view points to "triangulate" points of interest on the object in three-dimensional ("3D") space. This triangulation can be visualized as a process of projecting a line originating from the location of the photograph's observation point that passes through a particular reference point in the image. The intersection of these projected lines from the set of observation points to a particular reference point identifies the location of that point in 3D space. Repeating the process for all such reference points allows the software to build a 3D model of the structure.

The optimal choice of reconstruction algorithm depends on a number of factors such as the spatial relationships between the photographs, the number and locations of the reference points, and any assumptions that are made about the geometry and symmetry of the object being reconstructed. Several such algorithms are described in detail in textbooks, trade journals, and academic publications.

Once the reconstruction of the building is complete, the results may be reviewed for completeness and correctness. If necessary, an operator of the service's **70** software will make corrections to the reconstructed model.

Information from the reconstructed model may then be used to generate a report containing information relevant to the customer. The information in the report may include total square footage, square footage and pitch of each section of roof, linear measurements of all roof segments, identification and measurement of ridges and valleys, and different elevation views rendered from the 3D model (top, side, front, etc).

Using the above description, a method for estimating the size and the repair or replacement costs of a roof may include the following steps:

a. selecting a roof estimation system that includes a computer with a roof estimation software program loaded into its working memory, said roof estimation software uses aerial image files of buildings in a selected region and a calibration module that allows the size, geometry, and orientation of a roof section to be determined from said aerial image files;

b. submitting a request for a measurement of a roof of a building at a known location;

c. submitting the location information of a building with a roof that needs a size determination, a repair estimate, or replacement estimate;

d. entering the location information of said building and obtaining aerial image files of one or more roof sections used on a roof; and,

e. using said calibration module to determine the size, geometry and pitch of each said roof section.

In the above method, the entity requesting the measurement may be a roof construction/repair company, the building tenant, the building owner, an insurance company, etc.

FIG. **6** is a block diagram illustrating example functional elements of one embodiment of a roof estimation system. In particular, FIG. **6** shows an example Roof Estimation System ("RES") **600** comprising an image acquisition engine **601**, a roof modeling engine **602**, a report generation engine **603**, image data **605**, model data **606**, and report data **607**. The RES **600** is communicatively coupled to an image source **610**, a customer **615**, and optionally an operator **620**. The RES **600** and its components may be implemented as part of a computing system, as will be further described with reference to FIG. **7**.

In the illustrated embodiment, the RES **600** performs some or all of the functions of the whole system described with reference to FIGS. **1** and **2**, and also additional functions as described below. For example, the RES **600** may perform one or more of the functions of the software program **50**, the roof estimating entity **105**, the aerial image file database **52**, and/or the calibration module **56**.

More specifically, in the illustrated embodiment of FIG. **6**, the RES **600** is configured to generate a roof estimate report **632** for a specified building, based on aerial images **631** of the building received from the image source **610**. The image source **610** may be any provider of images of the building for which a roof estimate is being generated. In one embodiment, the image source **610** includes a computing system that provides access to a repository of aerial images of one or more buildings. The image acquisition engine **601** obtains one or more aerial images of the specified building by, for example, providing an indicator of the location of the specified building (e.g., street address, GPS coordinates, lot number, etc.) to the image source **610**. In response, the image source **610** provides to the image acquisition engine **605** the one or more aerial images of the building. The image acquisition engine **601** then stores the received aerial images as image data **605**, for further processing by other components of the RES **600**. In some embodiments, the aerial images may include images obtain via one or more ground-based platforms, such as a vehicle-mounted camera that obtains street-level images of buildings, a nearby building, a hilltop, etc. In some cases, a vehicle-mounted camera may be mounted in an elevated position, such as a boom.

Next, the roof modeling engine **602** generates a model of the roof of the specified building. In the illustrated embodiment, the roof modeling engine **602** generates a three-dimensional model, although in other embodiments, a two-dimensional (e.g., top-down roof plan) may be generated instead or in addition. As noted above, a variety of automatic and semi-automatic techniques may be employed to generate a model of the roof of the building. In one embodiment, generating such a model is based at least in part on a correlation between at least two of the aerial images of the building. For example, the roof modeling engine **602** receives an indication of a corresponding feature that is shown in each of the two aerial images. In one embodiment, an operator **620**, viewing two or more images of the building, inputs an indication in at least some of the images, the indications identifying which points of the images correspond to each other for model generation purposes.

The corresponding feature may be, for example, a vertex of the roof of the building, the corner of one of the roof planes of the roof, a point of a gable or hip of the roof, etc. The corresponding feature may also be a linear feature, such as a ridge or valley line between two roof planes of the roof. In one embodiment, the indication of a corresponding feature on the building includes "registration" of a first point in a first aerial image, and a second point in a second aerial image, the first and second points corresponding the substantially the same point on the roof of the building. Generally, point registration may include the identification of any feature shown in both aerial images. Thus, the feature need not be a point on the roof of the building. Instead, it may be, for example, any point that is visible on both aerial images, such as on a nearby building (e.g., a garage, neighbor's building, etc.), on a nearby structure (e.g., swimming pool, tennis court, etc.), on a nearby natural feature (e.g., a tree, boulder, etc.), etc.

In some embodiments, the roof modeling engine **602** determines the corresponding feature automatically, such as by employing on one or more image processing techniques used to identify vertexes, edges, or other features of the roof. In other embodiments, the roof modeling engine **602** determines the corresponding feature by receiving, from the human operator **620** as operator input **633**, indications of the feature shown in multiple images of the building.

In addition, generating a 3D model of the roof of a building may include correcting one or more of the aerial images for various imperfections. For example, the vertical axis of a particular aerial image sometimes will not substantially match the actual vertical axis of its scene. This will happen, for example, if the aerial images were taken at different distances from the building, or at a different pitch, roll, or yaw angles of the aircraft from which the images were produced. In such cases, an aerial image may be corrected by providing the operator **620** with a user interface control operable to adjust the scale and/or relative angle of the aerial image to

correct for such errors. The correction may be either applied directly to the aerial image, or instead be stored (e.g., as an offset) for use in model generation or other functions of the RES **600**.

Generating a 3D model of the roof of a building further includes the automatic or semi-automatic identification of features of the roof of the building. In one embodiment, one or more user interface controls may be provided, such that the operator **620** may indicate (e.g., draw, paint, etc.) various features of the roof, such as valleys, ridges, hips, vertexes, planes, edges, etc. As these features are indicated by the operator **620**, a corresponding 3D model may be updated accordingly to include those features. These features are identified by the operator based on a visual inspection of the images and by providing inputs that identify various features as valleys, ridges, hips, etc. In some cases, a first and a second image view of the roof (e.g., a north and east view) are simultaneously presented to the operator **620**, such that when the operator **620** indicates a feature in the first image view, a projection of that feature is automatically presented in the second image view. By presenting a view of the 3D model, simultaneously projected into multiple image views, the operator **620** is provided with useful visual cues as to the correctness of the 3D model and/or the correspondence between the aerial images.

In addition, generating a 3D model of the roof of a building may include determining the pitch of one or more of the sections of the roof. In some embodiments, one or more user interface controls are provided, such that the operator **620** may accurately determine the pitch of each of the one or more roof sections. An accurate determination of the roof pitch may be employed (by a human or the RES **600**) to better determine an accurate cost estimate, as roof sections having a low pitch are typically less costly surfaces to repair and/or replace.

The generated 3D model typically includes a plurality of planar roof sections that each correspond to one of the planar sections of the roof of the building. Each of the planar roof sections in the model has a number of associated dimensions and/or attributes, among them slope, area, and length of each edge of the roof section. Other information may include, whether a roof section edge is in a valley or on a ridge of the roof, the orientation of the roof section, and other information relevant to roof builder (e.g., roof and/or roof section perimeter dimensions and/or outlines). Once a 3D model has been generated to the satisfaction of the roof modeling engine **602** and/or the operator **620**, the generated 3D model is stored as model data **606** for further processing by the RES **600**. In one embodiment, the generated 3D model is then stored in a quality assurance queue, from which it is reviewed and possibly corrected by a quality control operator.

The report generation engine **603** generates a final roof estimate report based on a 3D model stored as model data **606**, and then stores the generated report as report data **607**. Such a report typically includes one or more plan (top-down) views of the 3D model, annotated with numerical values for the slope, area, and/or lengths of the edges of at least some of the plurality of planar roof sections of the 3D model of the roof. For example, the example report of FIGS. **5A-5E** includes multiple plan views of a generated 3D model of the house **103*c***. In particular, FIG. **5C** shows a first plan view of the 3D model, annotated with dimensions of the edges of each roof section. FIG. **5D** shows a second plan view of the same 3D model, annotated with the slope of each roof section. FIG. **5E** shows a third plan view of the same 3D model, annotated with the area of each roof section.

In some embodiments, generating a report includes labeling one or more views of the 3D model with annotations that are readable to a human user. Some 3D models include a large number of small roof details, such as dormers or other sections, such that applying uniformly sized, oriented, and positioned labels to roof section views results in a visually cluttered diagram. Accordingly, various techniques may be employed to generate a readable report, including automatically determining an optimal or near-optimal label font size, label position, and/or label orientation, such that the resulting report may be easily read and understood by the customer **615**.

In addition, in some embodiments, generating a report includes automatically determining a cost estimate, based on specified costs, such as those of materials, labor, transportation, etc. For example, the customer **615** provides indications of material and labor costs to the RES **600**. In response, the report generation engine **603** generates a roof estimate report that includes a cost estimate, based on the costs provided by the customer **615** and the attributes of the particular roof, such as area, pitch, etc.

In one embodiment, the generated report is then provided to a customer. The generated report can be represented, for example, as an electronic file (e.g., a PDF file) or a paper document. In the illustrated example, roof estimate report **632** is transmitted to the customer **615**. The customer **615** may be or include any human, organization, or computing system that is the recipient of the roof estimate report **632**. The customer **615** may be a property owner, a property manager, a roof construction/repair company, a general contractor, an insurance company, a solar power panel installer, etc. Reports may be transmitted electronically, such as via a network (e.g., as an email, Web page, etc.) or by some shipping mechanism, such as the postal service, a courier service, etc.

In some embodiments, one or more of the 3D models stored as model data **606** are provided directly to the customer, without first being transformed into a report. For example, a 3D model may be exported as a data file, in any acceptable format, that may be consumed or otherwise utilized by some other computing system, such as computer-aided design ("CAD") tool, drawing program, etc.

FIG. **7** is an example block diagram of a computing system for practicing embodiments of a roof estimation system. FIG. **7** shows a computing system **700** that may be utilized to implement a Roof Estimation System ("RES") **710**. One or more general purpose or special purpose computing systems may be used to implement the RES **710**. More specifically, the computing system **700** may comprise one or more distinct computing systems present at distributed locations. In addition, each block shown may represent one or more such blocks as appropriate to a specific embodiment or may be combined with other blocks. Moreover, the various blocks of the RES **710** may physically reside on one or more machines, which use standard inter-process communication mechanisms (e.g., TCP/IP) to communicate with each other. Further, the RES **710** may be implemented in software, hardware, firmware, or in some combination to achieve the capabilities described herein.

In the embodiment shown, computing system **700** comprises a computer memory ("memory") **701**, a display **702**, one or more Central Processing Units ("CPU") **703**, Input/Output devices **704** (e.g., keyboard, mouse, CRT or LCD display, and the like), other computer-readable media **705**, and network connections **706**. The RES **710** is shown residing in memory **701**. In other embodiments, some portion of the contents, some of, or all of the components of the RES **710** may be stored on and/or transmitted over the other computer-readable media **705**. The components of the RES **710** preferably execute on one or more CPUs **703** and generate roof

estimate reports, as described herein. Other code or programs **730** (e.g., a Web server, a database management system, and the like) and potentially other data repositories, such as data repository **720**, also reside in the memory **710**, and preferably execute on one or more CPUs **703**. Not all of the components in FIG. **7** are required for each implementation. For example, some embodiments embedded in other software do not provide means for user input, for display, for a customer computing system, or other components.

In a typical embodiment, the RES **710** includes an image acquisition engine **711**, a roof modeling engine **712**, a report generation engine **713**, an interface engine **714**, and a roof estimation system data repository **716**. Other and/or different modules may be implemented. In addition, the RES **710** interacts via a network **750** with an image source computing system **755**, an operator computing system **765**, and/or a customer computing system **760**.

The image acquisition engine **711** performs at least some of the functions of the image acquisition engine **601** described with reference to FIG. **6**. In particular, the image acquisition engine **711** interacts with the image source computing system **755** to obtain one or more images of a building, and stores those images in the RES data repository **716** for processing by other components of the RES **710**. In some embodiments, the image acquisition engine **711** may act as an image cache manager, such that it preferentially provides images to other components of the RES **710** from the RES data repository **716**, while obtaining images from the image source computing system **755** when they are not already present in the RES data repository **716**.

The roof modeling engine **712** performs at least some of the functions of the roof modeling engine **602** described with reference to FIG. **6**. In particular, the roof modeling engine **712** generates a 3D model based on one or more images of a building that are obtained from the RES data repository **716**. As noted, 3D model generation may be performed semi-automatically, based on at least some inputs received from the computing system **765**. In addition, at least some aspects of the 3D model generation may be performed automatically, based on image processing and/or image understanding techniques. After the roof modeling engine **712** generates a 3D model, it stores the generated model in the RES data repository **716** for further processing by other components of the RES **710**.

The report generation engine **713** performs at least some of the functions of the report generation engine **603** described with reference to FIG. **6**. In particular, the report generation engine **713** generates roof reports based on 3D models stored in the RES data repository **716**. Generating a roof report may include preparing one or more views of a given 3D model of a roof, annotating those views with indications of various characteristics of the model, such as dimensions of sections or other features (e.g., ridges, valleys, etc.) of the roof, slopes of sections of the roof, areas of sections of the roof, etc.

The interface engine **714** provides a view and a controller that facilitate user interaction with the RES **710** and its various components. For example, the interface engine **714** provides an interactive graphical user interface that can be used by a human user operating the operator computing system **765** to interact with, for example, the roof modeling engine **612**, to perform functions related to the generation of 3D models, such as point registration, feature indication, pitch estimation, etc. In other embodiments, the interface engine **714** provides access directly to a customer operating the customer computing system **760**, such that the customer may place an order for a roof estimate report for an indicated building location. In at least some embodiments, access to the functionality of the interface engine **714** is provided via a Web server, possibly executing as one of the other programs **730**.

In some embodiments, the interface engine **714** provides programmatic access to one or more functions of the RES **710**. For example, the interface engine **714** provides a programmatic interface (e.g., as a Web service, static or dynamic library, etc.) to one or more roof estimation functions of the RES **710** that may be invoked by one of the other programs **730** or some other module. In this manner, the interface engine **714** facilitates the development of third-party software, such as user interfaces, plug-ins, adapters (e.g., for integrating functions of the RES **710** into desktop applications, Web-based applications, embedded applications, etc.), and the like. In addition, the interface engine **714** may be in at least some embodiments invoked or otherwise accessed via remote entities, such as the operator computing system **765**, the image source computing system **755**, and/or the customer computing system **760**, to access various roof estimation functionality of the RES **710**.

The RES data repository **716** stores information related the roof estimation functions performed by the RES **710**. Such information may include image data **605**, model data **606**, and/or report data **607** described with reference to FIG. **6**. In addition, the RES data repository **716** may include information about customers, operators, or other individuals or entities associated with the RES **710**.

In an example embodiment, components/modules of the RES **710** are implemented using standard programming techniques. For example, the RES **710** may be implemented as a "native" executable running on the CPU **703**, along with one or more static or dynamic libraries. In other embodiments, the RES **710** is implemented as instructions processed by virtual machine that executes as one of the other programs **730**. In general, a range of programming languages known in the art may be employed for implementing such example embodiments, including representative implementations of various programming language paradigms, including but not limited to, object-oriented (e.g., Java, C++, C#, Visual Basic.NET, Smalltalk, and the like), functional (e.g., ML, Lisp, Scheme, and the like), procedural (e.g., C, Pascal, Ada, Modula, and the like), scripting (e.g., Perl, Ruby, Python, JavaScript, VBScript, and the like), declarative (e.g., SQL, Prolog, and the like).

The embodiments described above may also use well-known synchronous or asynchronous client-server computing techniques. However, the various components may be implemented using more monolithic programming techniques as well, for example, as an executable running on a single CPU computer system, or alternatively decomposed using a variety of structuring techniques known in the art, including but not limited to, multiprogramming, multithreading, client-server, or peer-to-peer, running on one or more computer systems each having one or more CPUs. Some embodiments execute concurrently and asynchronously, and communicate using message passing techniques. Equivalent synchronous embodiments are also supported by an RES implementation. Also, other functions could be implemented and/or performed by each component/module, and in different orders, and by different components/modules, yet still achieve the functions of the RES.

In addition, programming interfaces to the data stored as part of the RES **710**, such as in the RES data repository **716**, can be available by standard mechanisms such as through C, C++, C#, and Java APIs; libraries for accessing files, databases, or other data repositories; through scripting languages such as XML; or through Web servers, FTP servers, or other types of servers providing access to stored data. For example,

the RES data repository **716** may be implemented as one or more database systems, file systems, memory buffers, or any other technique for storing such information, or any combination of the above, including implementations using distributed computing techniques.

Also, the example RES **710** can be implemented in a distributed environment comprising multiple, even heterogeneous, computer systems and networks. For example, in one embodiment, the image acquisition engine **711**, the roof modeling engine **712**, the report generation engine **713**, the interface engine **714**, and the data repository **716** are all located in physically different computer systems. In another embodiment, various modules of the RES **710** are hosted each on a separate server machine and are remotely located from the tables which are stored in the data repository **716**. Also, one or more of the modules may themselves be distributed, pooled or otherwise grouped, such as for load balancing, reliability or security reasons. Different configurations and locations of programs and data are contemplated for use with techniques of described herein. A variety of distributed computing techniques are appropriate for implementing the components of the illustrated embodiments in a distributed manner including but not limited to TCP/IP sockets, RPC, RMI, HTTP, Web Services (XML-RPC, JAX-RPC, SOAP, and the like).

Furthermore, in some embodiments, some or all of the components of the RES are implemented or provided in other manners, such as at least partially in firmware and/or hardware, including, but not limited to one or more application-specific integrated circuits (ASICs), standard integrated circuits, controllers (e.g., by executing appropriate instructions, and including microcontrollers and/or embedded controllers), field-programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), and the like Some or all of the system components and/or data structures may also be stored (e.g., as software instructions or structured data) on a computer-readable medium, such as a hard disk, a memory, a network, or a portable media article to be read by an appropriate drive or via an appropriate connection. The system components and data structures may also be stored as data signals (e.g., by being encoded as part of a carrier wave or included as part of an analog or digital propagated signal) on a variety of computer-readable transmission mediums, which are then transmitted, including across wireless-based and wired/cable-based mediums, and may take a variety of forms (e.g., as part of a single or multiplexed analog signal, or as multiple discrete digital packets or frames). Such computer program products may also take other forms in other embodiments. Accordingly, embodiments of this disclosure may be practiced with other computer system configurations.

FIG. **8** is an example flow diagram of a first example roof estimation routine provided by an example embodiment. The illustrated routine **800** may be provided by, for example, execution of the roof estimation system **710** described with respect to FIG. **7**. The illustrated routine **800** generates a 3D model of a roof of a building, based on two or more aerial images of the building, and further prepares and transmits a roof estimate report based on the 3D model.

More specifically, the routine begins at step **801** where it receives a first and a second aerial image of a building, each of the aerial images providing a different view of the roof of the building. The aerial images may be received from, for example, the image source computing system **755** and/or from the RES data repository **716** described with reference to FIG. **7**. As discussed above, aerial images may be originally created by cameras mounted on airplanes, balloons, satellites, etc. In some embodiments, images obtained from ground-based platforms (e.g., vehicle-mounted cameras) may be used instead or in addition.

In step **802**, the routine correlates the first aerial image with the second aerial image. In some embodiments, correlating the aerial images may include registering pairs of points on the first and second aerial images, each pair of points corresponding to substantially the same point on the roof depicted in each of the images. Correlating the aerial images may be based at least in part on input received from a human operator and/or automatic image processing techniques.

In step **803**, the routine generates, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof. The three-dimensional model of the roof may include a plurality of planar roof sections that each have a corresponding slope, area, and perimeter. Generating the three-dimensional model may be based at least in part indications of features of the roof, such as valleys, ridges, edges, planes, etc. Generating the three-dimensional model may also be based at least in part on input received from a human operator (e.g., indications of roof ridges and valleys) and/or automatic image processing techniques.

In step **804**, the routine prepares (e.g., generates, determines, produces, etc.) and transmits a roof estimate report that includes one or more annotated top-down views of the three-dimensional model. In some embodiments, the annotations include numerical values indicating the slope, area, and lengths of the edges of the perimeter of at least some of the plurality of planar roof sections of the three-dimensional model of the roof. The roof estimate report may be an electronic file that includes images of the building and/or its roof, as well as line drawings of one or more views of the three-dimensional model of the building roof. Preparing the report may include annotating the report with labels that are sized and oriented in a manner that preserves and/or enhances readability of the report. For example, labels on a particular line drawing may be sized based at least in part on the size of the feature (e.g., roof ridge line) that they are associated with, such that smaller features are annotated with smaller labels so as to preserve readability of the line drawing by preventing or reducing the occurrence of labels that overlap with other portions (e.g., lines, labels, etc.) of the line drawing. The roof estimate report may be transmitted to various destinations, such as directly to a customer or computing system associated with that customer, a data repository, and/or a quality assurance queue for inspection and/or improvement by a human operator.

After step **804**, the routine ends. In other embodiments, the routine may instead return to step **801**, to generate another roof estimate report for another building. Note that the illustrated routine may be performed interactively, such as based at least in part on one or more inputs received from a human operator, or in batch mode, such as for performing automatic, bulk generation of roof estimate reports.

FIG. **9** is an example flow diagram of a second example roof estimation routine provided by an example embodiment. The illustrated routine **900** may be provided by, for example, execution of the roof estimation system **710** described with respect to FIG. **7**. The illustrated routine **900** generates a roof estimate report based on a single aerial image and additional information received from a user, such as information about the pitch of various roof sections.

In step **901**, the routine receives a substantially top-down aerial image of a building having a roof. Such an aerial image may be obtained from, for example, a satellite or aircraft.

In step **902**, the routine generates a preliminary model of the roof based on the received aerial image. The preliminary roof model may be a two-dimensional ("flat") model that includes information about the perimeter of the roof and at least some of its corresponding planar roof sections. Such a preliminary roof model may include estimates of various dimensions of the roof, such as edge lengths and/or section areas. In some cases, the preliminary roof model does not include information related to the pitch of various roof sections.

In step **903**, the routine modifies the preliminary model based on additional information about the roof received from a user. For example, the preliminary model may be presented to a user (e.g., a customer, an operator, etc.), by displaying a representation of the model, such as a line drawing. In response, the user provides the routine with pitch information and/or feature identification (e.g., of ridges and/or valleys), etc. Such user-supplied information is then incorporated into the preliminary roof model to obtain a modified (refined) roof model. In some cases, the user supplies the additional information via a Web-base interface that provides access to the routine.

In step **904**, the routine prepares and transmits a roof estimate report that includes one or more annotated views of the modified model. As discussed above, the annotations may include numerical values indicating the slope, area, and lengths of the edges of the perimeter of at least some of the roof sections of the roof. After step **904**, the routine ends.

The routines **800** and **900** may be used in conjunction to advantageously offer customers roof estimate reports at differing price points. For example, routine **800** can be utilized as part of a "premium" service that offers a customer with a more accurate roof estimate report for minimal effort on the customer's part. Routine **900** can be utilized as part of an "economy" service that offers a customer a less accurate roof estimate report at a lower price, but that may be further refined with additional effort from the customer.

From the foregoing it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the present disclosure. For example, the methods, systems, and techniques for generating and providing roof estimate reports discussed herein are applicable to other architectures other than the illustrated architecture or a particular roof estimation system implementation. Also, the methods and systems discussed herein are applicable to differing network protocols, communication media (optical, wireless, cable, etc.) and devices (such as wireless handsets, electronic organizers, personal digital assistants, portable email machines, game machines, pagers, navigation devices such as GPS receivers, etc.). Further, the methods and systems discussed herein may be utilized by and/or applied to other contexts or purposes, such as by or for solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and/or insurance companies.

The invention claimed is:

1. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

receive a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building;

correlate the first aerial image with the second aerial image;

generate, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

generate and transmit a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical values that indicate the corresponding slope, area, and length of edges of at least some of the plurality of planar roof sections using at least two different indicia for different types of roof properties.

2. The computing system of claim **1** wherein the roof estimation module is further configured to correlate the first and second aerial images by receiving an indication of one or more corresponding points on the building shown in each of the first and second aerial images.

3. The computing system of claim **1** wherein the roof estimation module is further configured to generate the three-dimensional model by receiving an indication of at least one of a ridgeline of the roof, a valley of the roof, an edge of the roof, a hip of the roof, and a gable of the roof.

4. The computing system of claim **1** wherein the roof estimation module is further configured to receive the first and second aerial image from an image source computing system.

5. The computing system of claim **1** wherein the roof estimation module is further configured to generate the roof estimate report by generating an electronic file that includes an image of the building along with line drawings of the one or more top plan views of the three-dimensional model.

6. The method of claim **1** wherein transmitting the roof estimate report includes initiating printing of the one or more top plan views of the three-dimensional model.

7. The computing system of claim **1** wherein the different types of roof properties include different roof measurements, and the at least two different indicia include at least one of: length, slope, and area.

8. The computing system of claim **7** wherein the length is located adjacent to a line representing a segment, the slope is located next to an arrow indicating direction of the slope and the area is located within a section having the area.

9. The computing system of claim **1** wherein the different types of roof properties include different roof features, and the at least two different indicia include different graphical representations of the different roof features.

10. The computing system of claim **1** wherein the different types of roof properties include a ridge line and a valley line and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

11. The computing system of claim **1** wherein the different types of roof properties include at least one of: a roof section, a roof segment, a roof valley, a ridge, a roof size, a roof geometry, a roof measurement, a roof dimension, slope, length and area.

12. The computing system of claim **1** wherein the at least two different indicia include at least one of: different line color, different line weight, different visual characteristics of a line, different characters, different color of characters, different visual characteristics of characters, different measurements, different visual characteristics of measurements, different placement of measurements with respect to lines, different symbols, different visual characteristics of symbols and different placement of measurements with respect to symbols.

13. The computing system of claim 1 wherein the different types of roof properties include a ridge length and a valley length and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

14. The computing system of claim 13 wherein the one color of the line associated with the ridge is red and the different color of the line associated with the valley is blue.

15. The computing system of claim 1 wherein the different types of roof properties include a ridge and the at least two different indicia include a ridge length indicia, wherein the ridge length indicia is a ridge line with a numerical value adjacent thereto.

16. The computing system of claim 1 wherein the different types of roof properties include a valley and the at least two different indicia include a valley length indicia, wherein the valley length indicia is a valley line with a numerical value adjacent thereto.

17. The computing system of claim 1 wherein the different types of roof properties include a slope and the at least two different indicia include a slope indicia, wherein the slope indicia is an arrow in a direction of the slope with a numerical value adjacent thereto.

18. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building;

correlating the first aerial image with the second aerial image;

generating, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

transmitting a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical indications of at least one of the slope, area, and lengths of the edges of the plurality of planar roof sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

19. The method of claim 18 wherein identifying the building includes receiving a street address of the building.

20. The method of claim 18 wherein correlating the first and second aerial images includes receiving an indication of one or more corresponding points shown in each of the first and second aerial images.

21. The method of claim 20 wherein receiving the indication of the corresponding point includes receiving the indication from a user.

22. The method of claim 18 wherein generating the three-dimensional model includes receiving an indication of at least one of a ridgeline of the roof, a valley of the roof, an edge of the roof, a hip of the roof, and a gable of the roof.

23. The method of claim 18, further comprising generating the roof estimate report, the roof estimate report being a data file that includes an image of the building along with line drawings of the one or more top plan views of the three-dimensional model.

24. The method of claim 18 wherein transmitting the roof estimate report includes transmitting a data file that includes the one or more top plan views of the three-dimensional model.

25. The method of claim 18 wherein the different types of roof properties include different roof measurements, and the at least two different indicia include at least one of: length, slope, and area.

26. The method of claim 25 wherein the length is located adjacent to a line representing a segment, the slope is located next to an arrow indicating direction of the slope and the area is located within a section having the area.

27. The method of claim 18 wherein the different types of roof properties include different roof features, and the at least two different indicia include different graphical representations of the different roof features.

28. The method of claim 18 wherein the different types of roof properties include a ridge line and a valley line and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

29. The method of claim 18 wherein the different types of roof properties include at least one of: a roof section, a roof segment, a roof valley, a ridge, a roof size, a roof geometry, a roof measurement, a roof dimension, slope, length and area.

30. The method of claim 18 wherein the at least two different indicia include at least one of: different line color, different line weight, different visual characteristics of a line, different characters, different color of characters, different visual characteristics of characters, different measurements, different visual characteristics of measurements, different placement of measurements with respect to lines, different symbols, different visual characteristics of symbols and different placement of measurements with respect to symbols.

31. The method of claim 18 wherein the different types of roof properties include a ridge length and a valley length and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

32. The method of claim 31 wherein the one color of the line associated with the ridge is red and the different color of the line associated with the valley is blue.

33. The method of claim 18 wherein the different types of roof properties include a ridge and the at least two different indicia include a ridge length indicia, wherein the ridge length indicia is a ridge line with a numerical value adjacent thereto.

34. The method of claim 18 wherein the different types of roof properties include a valley and the at least two different indicia include a valley length indicia, wherein the valley length indicia is a valley line with a numerical value adjacent thereto.

35. The method of claim 18 wherein the different types of roof properties include a slope and the at least two different indicia include a slope indicia, wherein the slope indicia is an arrow in a direction of the slope with a numerical value adjacent thereto.

36. A non-transitory computer-readable storage medium whose contents enable a computing system to generate a roof estimate report for a building having a roof, by performing a method comprising:

receiving one or more images of the building;

generating, based on the one or more images of the building, a model of the roof that includes a plurality of planar roof sections that each have a corresponding area and edges; and

transmitting a roof estimate report that includes one or more views of the model, the report being annotated with numerical indications of the area and lengths of the edges of at least some of the plurality of planar roof

sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

37. The non-transitory computer-readable storage medium of claim 36 wherein generating the model includes generating a three-dimensional model based on a correlation between two of the one or more images.

38. The non-transitory computer-readable storage medium of claim 36 wherein the method further comprises generating the roof estimate report, the roof estimate report including annotated line drawings of each of the one or more views of the model.

39. The non-transitory computer-readable storage medium of claim 36 wherein the one or more images of the building are images obtained from at least one of an aircraft, satellite, and ground-based platform, and wherein the one or more views of the model are top-down line drawing views of the model.

40. The non-transitory computer-readable storage medium of claim 36 wherein generating the model of the roof includes automatically identifying at least some features of the roof for inclusion in the model.

41. The non-transitory computer-readable storage medium of claim 36 wherein the contents are instructions that when executed cause the computing system to perform the method.

42. The non-transitory computer-readable storage medium of claim 36 wherein the method further comprises transmitting to a remote computing system a computer-readable data file that includes a representation of the model.

43. The non-transitory computer-readable storage medium of claim 36 wherein generating the model of the roof includes generating a two-dimensional model of the roof based on a single image that provides a substantially top-down view of the roof.

44. The non-transitory computer-readable storage medium of claim 43 further comprising:

presenting the model to a customer; and

modifying the model of the roof based on input received from the customer, the input indicating a slope corresponding to one of the plurality of planar roof sections, wherein transmitting the roof estimate report includes generating a roof estimate report based on the modified model.

45. The non-transitory computer-readable storage medium of claim 43 further comprising:

modifying the model of the roof based on input received from a customer, the input identifying a ridge or valley of the roof, wherein transmitting the roof estimate report includes generating a roof estimate report based on the modified model.

46. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include different roof measurements, and the at least two different indicia include at least one of: length, slope, and area.

47. The non-transitory computer-readable storage medium of claim 46 wherein the length is located adjacent to a line representing a segment, the slope is located next to an arrow indicating direction of the slope and the area is located within a section having the area.

48. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include different roof features, and the at least two different indicia include different graphical representations of the different roof features.

49. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include a ridge line and a valley line and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

50. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include at least one of: a roof section, a roof segment, a roof valley, a ridge, a roof size, a roof geometry, a roof measurement, a roof dimension, slope, length and area.

51. The non-transitory computer-readable storage medium of claim 36 wherein the at least two different indicia include at least one of: different line color, different line weight, different visual characteristics of a line, different characters, different color of characters, different visual characteristics of characters, different measurements, different visual characteristics of measurements, different placement of measurements with respect to lines, different symbols, different visual characteristics of symbols and different placement of measurements with respect to symbols.

52. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include a ridge length and a valley length and the at least two different indicia include one color of a line associated with a ridge and a different color of a line associated with a valley.

53. The non-transitory computer-readable storage medium of claim 52 wherein the one color of the line associated with the ridge is red and the different color of the line associated with the valley is blue.

54. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include a ridge and the at least two different indicia include a ridge length indicia, wherein the ridge length indicia is a ridge line with a numerical value adjacent thereto.

55. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include a valley and the at least two different indicia include a valley length indicia, wherein the valley length indicia is a valley line with a numerical value adjacent thereto.

56. The non-transitory computer-readable storage medium of claim 36 wherein the different types of roof properties include a slope and the at least two different indicia include a slope indicia, wherein the slope indicia is an arrow in a direction of the slope with a numerical value adjacent thereto.

* * * * *

US008078436C1

(12) **EX PARTE REEXAMINATION CERTIFICATE** (11th)
Ex Parte Reexamination Ordered under 35 U.S.C. 257

United States Patent

Pershing et al.

(10) **Number: US 8,078,436 C1**
(45) **Certificate Issued: Aug. 27, 2014**

(54) **AERIAL ROOF ESTIMATION SYSTEMS AND METHODS**

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Supplemental Examination Request:
No. 96/000,004, Dec. 28, 2012

Reexamination Certificate for:
Patent No.: **8,078,436**
Issued: **Dec. 13, 2011**
Appl. No.: **12/253,092**
Filed: **Oct. 16, 2008**

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/148,439, filed on Apr. 17, 2008, now Pat. No. 8,145,578.

(60) Provisional application No. 60/925,072, filed on Apr. 17, 2007.

(51) **Int. Cl.**
G06F 7/60 (2006.01)
G06F 17/10 (2006.01)
G06Q 30/02 (2012.01)
G06T 17/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G06Q 30/02*** (2013.01); ***G06T 17/20*** (2013.01); ***G06Q 30/0283*** (2013.01); *G06T 2200/08* (2013.01)
USPC **703/2**

(58) **Field of Classification Search**
None
See application file for complete search history.

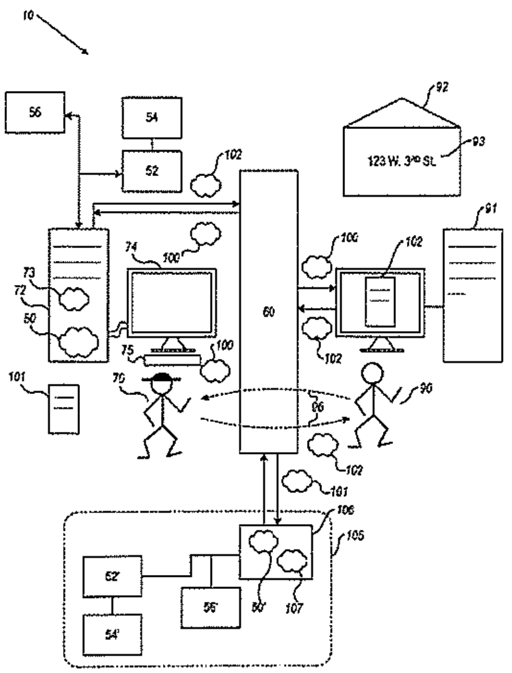
(56) **References Cited**

To view the complete listing of prior art documents cited during the supplemental examination proceeding and the resulting reexamination proceeding for Control Number 96/000,004, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Jason Proctor

(57) **ABSTRACT**

Methods and systems for roof estimation are described. Example embodiments include a roof estimation system, which generates and provides roof estimate reports annotated with indications of the size, geometry, pitch and/or orientation of the roof sections of a building. Generating a roof estimate report may be based on one or more aerial images of a building. *The slope and orientation images are typically oblique perspective views and top plan views of the buildings in the area.* In some embodiments, generating a roof estimate report of a specified building roof may include generating a three-dimensional model of the roof, and generating a report that includes one or more views of the three-dimensional model, the views annotated with indications of the dimensions, area, and/or slope of sections of the roof. This abstract is provided to comply with rules requiring an abstract, and it is submitted with the intention that it will not be used to interpret or limit the scope or meaning of the claims.



EX PARTE REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **43-45** are cancelled.

Claims **1**, **18**, **36**, **37** and **41** are determined to be patentable as amended.

Claims **2-17**, **19-35**, **38-40**, **42** and **46-56**, dependent on an amended claim, are determined to be patentable.

New claims **57-66** are added and determined to be patentable.

1. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

receive a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building, *wherein the first aerial image provides a top plan view of the roof and the second aerial image provides an oblique perspective view of the roof, and are not a stereoscopic pair*;

correlate the first aerial image with the second aerial image;

generate, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

generate and transmit a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical values that indicate the corresponding slope, area, and length of edges of at least some of the plurality of planar roof sections using at least two different indicia for different types of roof properties.

18. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building *wherein the first aerial image provides a top plan view of the roof and the second aerial image provides a view of the roof that is other than a top plan view and neither of the two images are part of a stereoscopic pair*;

correlating the first aerial image with the second aerial image;

generating, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

transmitting a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical indications of at least one of the slope, area, and lengths of the edges of the plurality of planar roof sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

36. A non-transitory computer-readable storage medium whose contents, *which are computer executable instructions stored on the non-transitory computer-readable storage medium, when executed by a computer processor of a computing system,* enable [a] *the* computing system to generate a roof estimate report for a building having a roof, by [performing] *causing, when executed by the computer processor of the computing system, the computing system to perform* a method comprising:

receiving [one] *two* or more images of the building, *wherein at least one of the two or more images provides an oblique perspective view of the roof and one of the images provides a top plan view of the roof;*

receiving an indication of pairs of points on the two or more images, each pair of points corresponding to substantially the same point on the roof depicted in each of the two or more images;

generating, based on the [one] *two* or more images of the building, a *three- dimensional* model of the roof that includes a plurality of planar roof sections that each have a corresponding area and edges, *wherein the generating, based on the two or more images of the building, the model of the roof includes generating the model of the roof based on the receiving the indication of the pairs of points on the two or more images of the building*; and

transmitting a roof estimate report that includes one or more views of the model, the report being annotated with numerical indications of the area and lengths of the edges of at least some of the plurality of planar roof sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

37. The non-transitory computer-readable storage medium of claim **36** wherein generating the model *of the roof based on the receiving the indication of the pairs of points on the two or more images* includes:

correlating two of the two or more images by registering the pairs of points; and

generating [a] *the* three-dimensional model based on [a] *the* correlation between *the* two of the [one] *two* or more images.

41. The non-transitory computer-readable storage medium of claim **36** wherein the contents are instructions that when executed cause the computing system to perform *the receiving two or more images step of* the method *by causing, when executed by the computer processor of the computing system, the computing system to provide access to a repository of aerial images of one or more buildings.*

57. The method according to 18 wherein the second aerial image provides an oblique perspective view of the roof.

58. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a first aerial image of a building having a type of view of the roof that is a top plan view of the roof;

receiving a second aerial image of the building having a type of view of the roof that is a perspective oblique view of the roof;

receiving a third aerial image having a type of view of the roof that is an oblique perspective from a different direc-

tion than the second aerial image, each of the aerial images providing a different view of the roof of the building;

correlating the first aerial image with the second aerial image and third aerial images;

generating, based at least in part on the correlation between the first, second and third aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

transmitting a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical indications of at least one of the slope, area, and lengths of the edges of the plurality of planar roof sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

59. The method of claim 58 wherein the different types of roof properties include a ridge line and a valley line and the at least two different indicia include one color of a line conveying the meaning of a roof ridge and a different color of a line conveying the meaning of roof valley.

60. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a first aerial image of a building;

receiving a second aerial image of the building having the roof;

receiving a third aerial image of the building, each of the aerial images providing a different view of the roof of the building;

correlating the first aerial image with the second aerial image and third aerial image;

generating, based at least in part on the correlation between the first, second and third aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

generating and transmitting a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical indications of at least one of the slope, area, and lengths of the edges of the plurality of planar roof sections, wherein the roof estimate report includes at least two different indicia for different types of roof properties.

61. The method of claim 60 wherein the correlating the first aerial image with the second and third aerial image includes receiving an indication of pairs of points on each of the images corresponding to substantially the same point on the roof depicted in each of the images.

62. The method of claim 61 wherein the correlating the first aerial image with the second and third aerial image further includes registering the pairs of points and the generating the three-dimensional model includes generating the three-dimensional model based on the registering of the pairs of points.

63. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a request for a roof estimate report for the roof of the building;

receiving location information regarding the building;

receiving a first aerial image of the building having the roof;

receiving a second aerial image of the building having the roof, the first and second images of the roof being independent of each in the views provided of the roof, each of the aerial images providing a different view of the roof of the building;

correlating the first aerial image with the second aerial image;

generating, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding pitch, area, and edges;

determining a pitch of a plurality of sections of the roof;

determining a direction of the pitch for each of the plurality of sections of the roof for which a pitch was determined;

generating a roof estimate report that includes a top plan views of the three-dimensional model annotated with numerical indications of the determined pitch and the direction of the pitch;

displaying on at least one top plan view a graphical indication of the pitch value of the respective roof sections that conveys the pitch value;

determining a ridge line and a valley line of the roof;

displaying on at least one top plan view a ridge line in which the property of it being a ridge line is conveyed by it being displayed in a first color and a valley line in which the property of it being a valley line is convey by it being in a second color, different from the first color; and

transmitting the generated roof report.

64. The method of claim 63 further comprising:

displaying on at least one top plan view of the roof a graphical indication of the pitch direction of the respective roof sections that conveys the direction of the pitch.

65. The method of claim 63 wherein the top plan view showing the pitch value is a different top plan view than the one showing the ridge line and the valley line.

66. The method of claim 65 wherein the correlating the first aerial image with the second aerial image further includes registering pairs of points and the generating the three-dimensional model includes generating the three-dimensional model based on the registering of the pairs of points.

* * * * *

Exhibit E

US008417061B2

(12) **United States Patent**
Kennedy et al.

(10) **Patent No.: US 8,417,061 B2**
(45) **Date of Patent: Apr. 9, 2013**

(54) **METHODS AND SYSTEMS FOR PROVISIONING ENERGY SYSTEMS**

(75) Inventors: **Daniel Ian Kennedy**, Berkeley, CA (US); **Adam Pryor**, Paddington NSW (AU); **Andrew Birch**, Ourca, CA (US)

(73) Assignee: **Sungevity Inc.**, Oakland, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 925 days.

(21) Appl. No.: **12/364,506**

(22) Filed: **Feb. 2, 2009**

(65) **Prior Publication Data**

US 2009/0304227 A1 Dec. 10, 2009

Related U.S. Application Data

(60) Provisional application No. 61/025,431, filed on Feb. 1, 2008, provisional application No. 61/047,086, filed on Apr. 22, 2008.

(51) **Int. Cl.**
G06K 9/32 (2006.01)

(52) **U.S. Cl.** **382/286**; 382/282; 382/291; 382/307; 703/1; 703/2

(58) **Field of Classification Search** 382/282, 382/291, 307; 703/1, 2
See application file for complete search history.

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Primary Examiner — Yosef Kassa
(74) *Attorney, Agent, or Firm* — Patrick M. Reilly

(57) **ABSTRACT**

The invention provides consumers, private enterprises, government agencies, contractors and third party vendors with tools and resources for gathering site specific information related to purchase and installation of energy systems. A system according to one embodiment of the invention remotely determines the measurements of a roof. An exemplary system comprises a computer including an input means, a display means and a working memory. An aerial image file database contains a plurality of aerial images of roofs of buildings in a selected region. A roof estimating software program receives location information of a building in the selected region and then presents the aerial image files showing roof sections of building located at the location information. Some embodiments of the system include a sizing tool for determining the size, geometry, and pitch of the roof sections of a building being displayed.

4 Claims, 19 Drawing Sheets

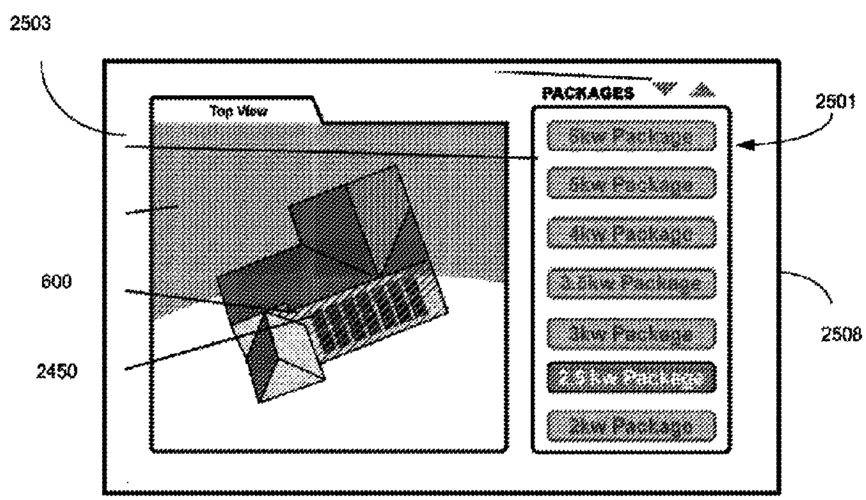

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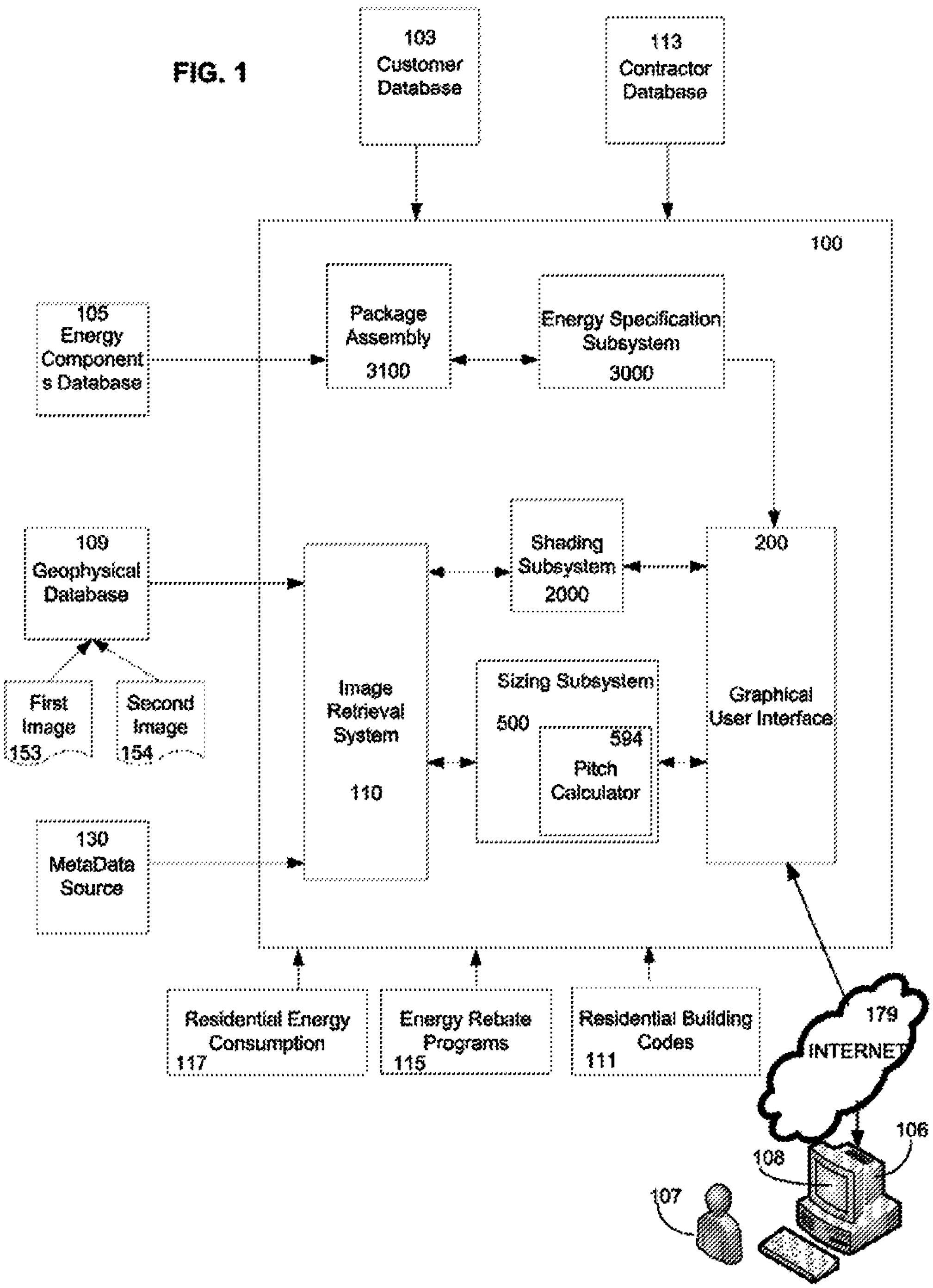
FIG. 1



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Contractor
Database
100
105
Energy
Components Database
Package
Assembly
3100
Energy Specification
Subsystem
3000
109
Geophysical
Database
Shading
Subsystem
2000
200
First
Image
153
Second
Image
154
Image
Retrieval
System
110
Sizing Subsystem
500
594
Pitch
Calculator
Graphical
User Interface
130
MetaData
Source
Residential Energy
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117
Energy Rebate
Programs
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Residential Building
Codes
111
179
INTERNET
106
108
107

FIG. 2

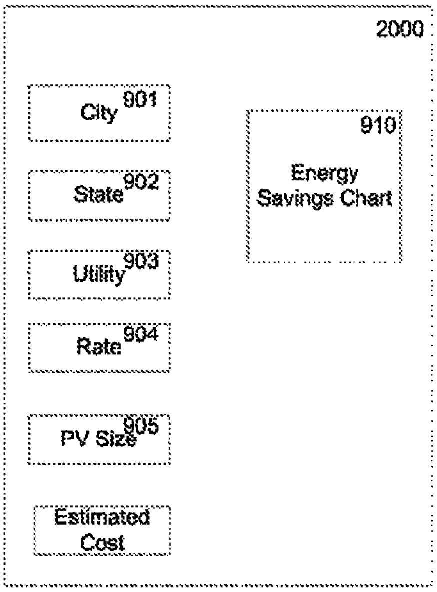


FIG.3

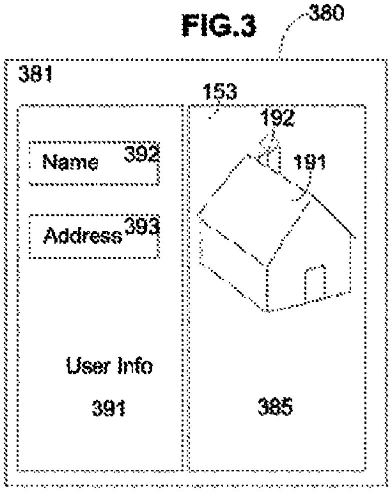


FIG.4

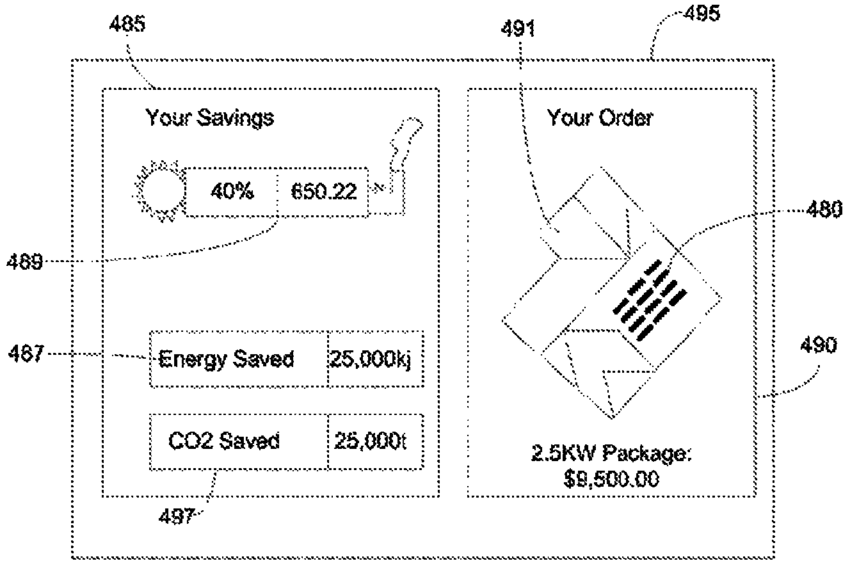
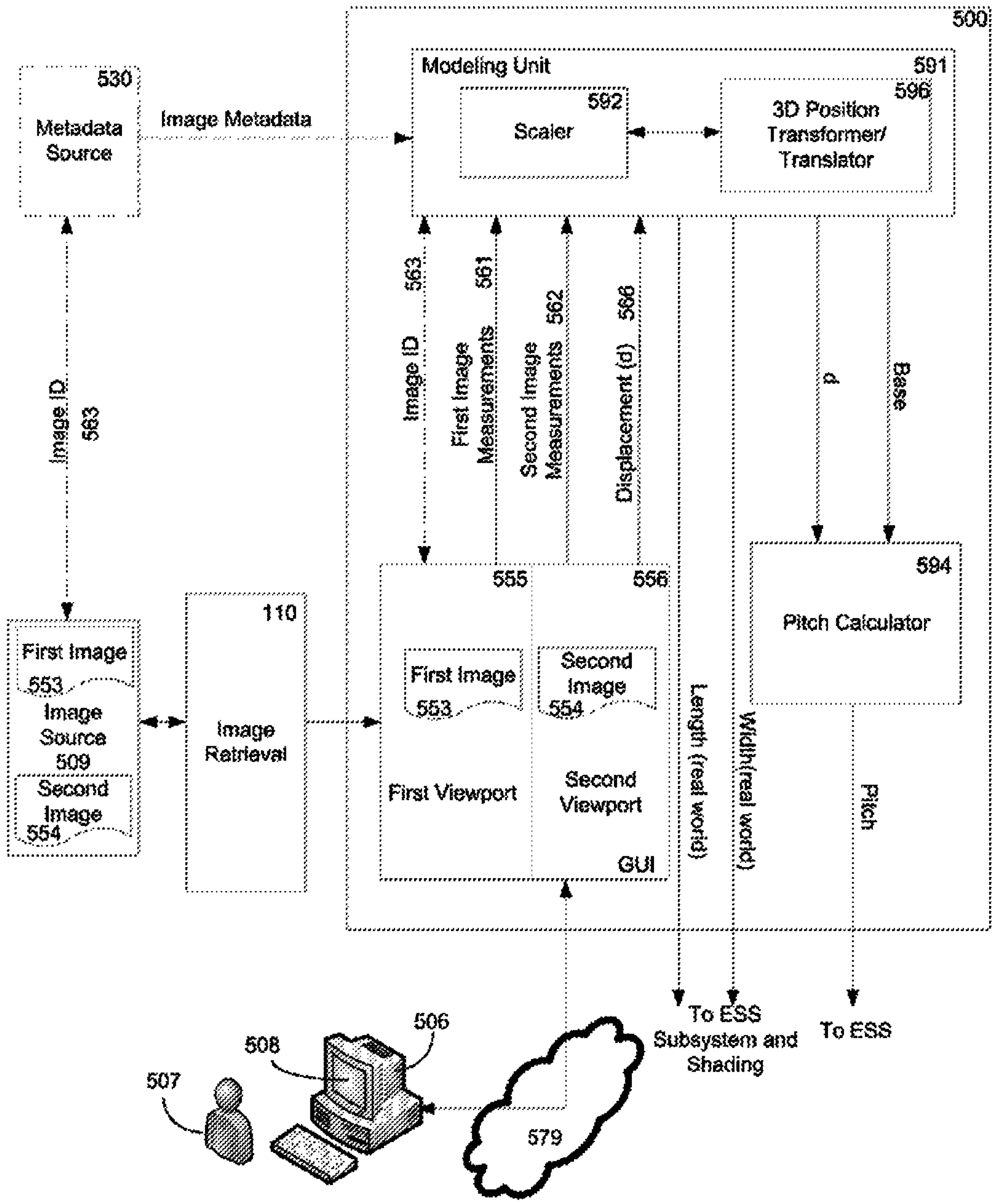


FIG. 5



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Modeling Unit
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592
Scaler
596
3D Position Transformer/ Translator
530
Metadata Source
Image Metadata
Image ID 563
Image ID 563
First Image Measurements 561
Second Image Measurements 562
Displacement (d) 566
d
Base
594
Pitch Calculator
555
556
First Image 553
Second Image 554
First Viewport
Second Viewport
GUI
110
Image Retrieval
First Image 553
Image Source 509
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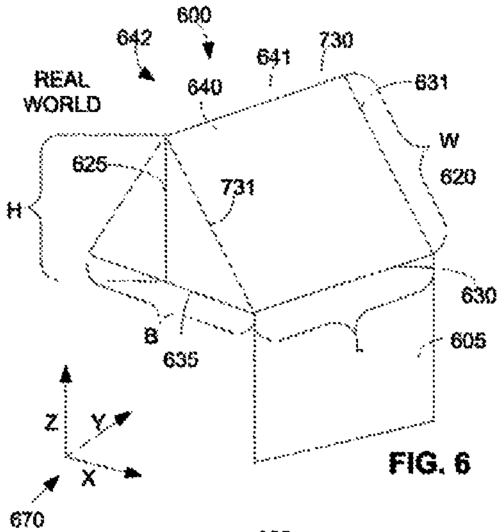
Length (real world)
Width(real world)
Pitch
To ESS Subsystem and Shading
To ESS
506
508
507
579



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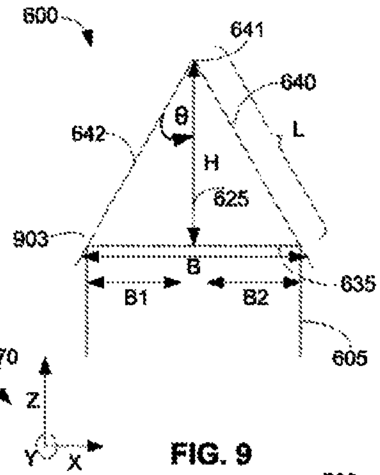


FIG. 9

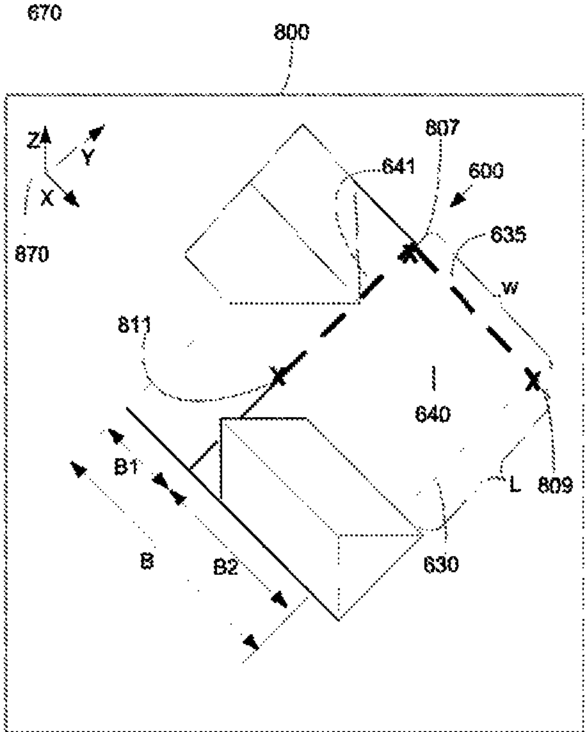


FIG. 8

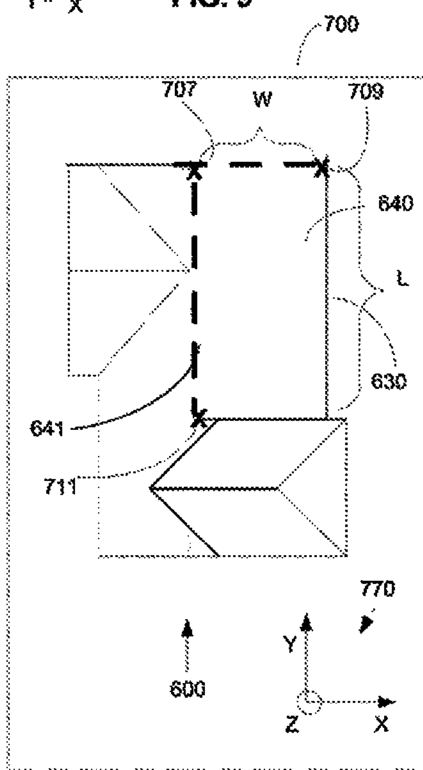


FIG. 7

FIG. 10

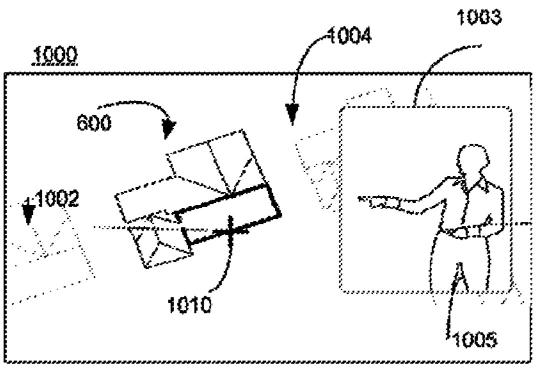
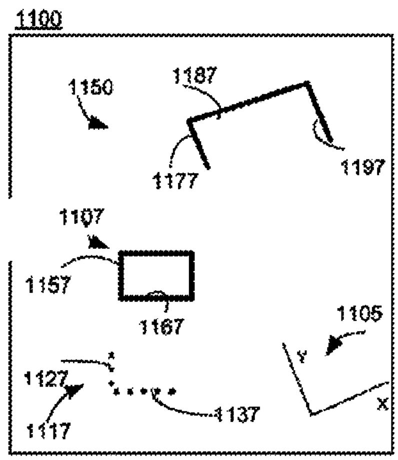


FIG. 11



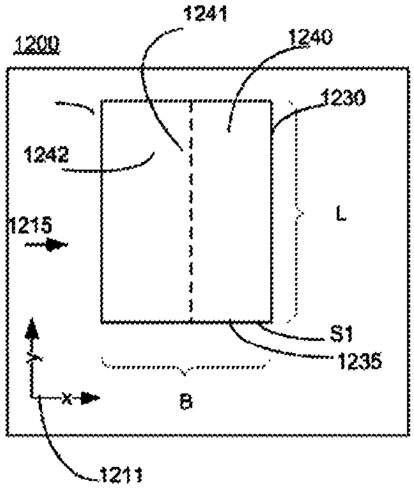


FIG. 12

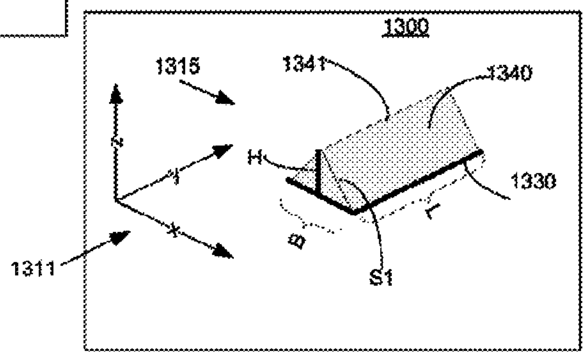


FIG. 13

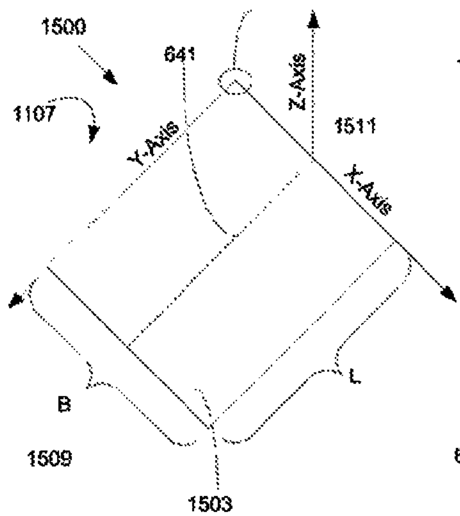


FIG. 15

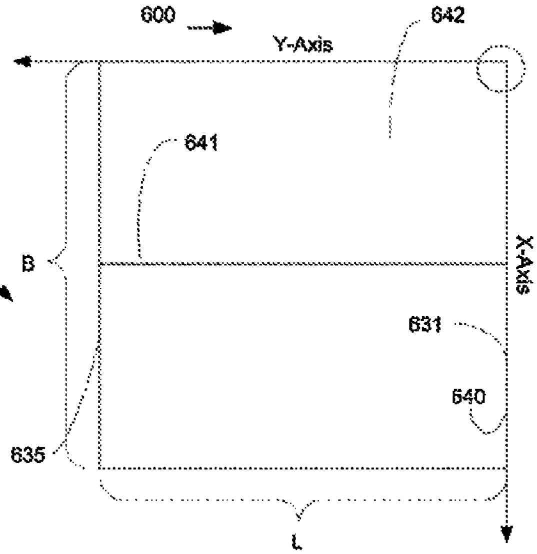


FIG. 14

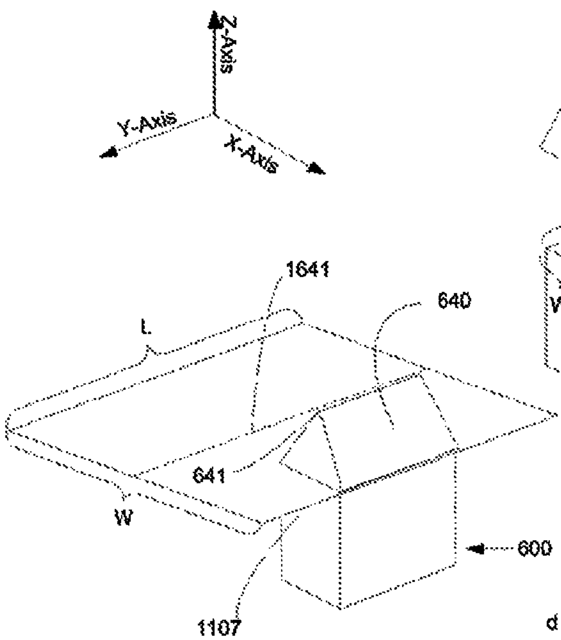


FIG. 16

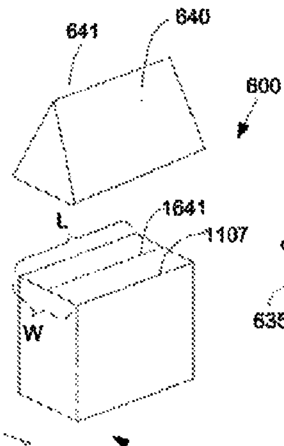


FIG. 17

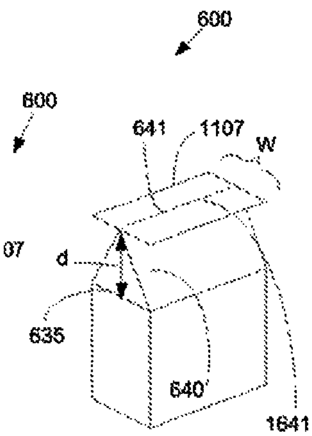
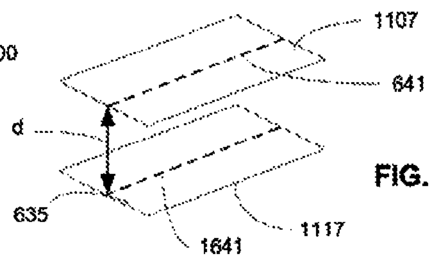


FIG. 18



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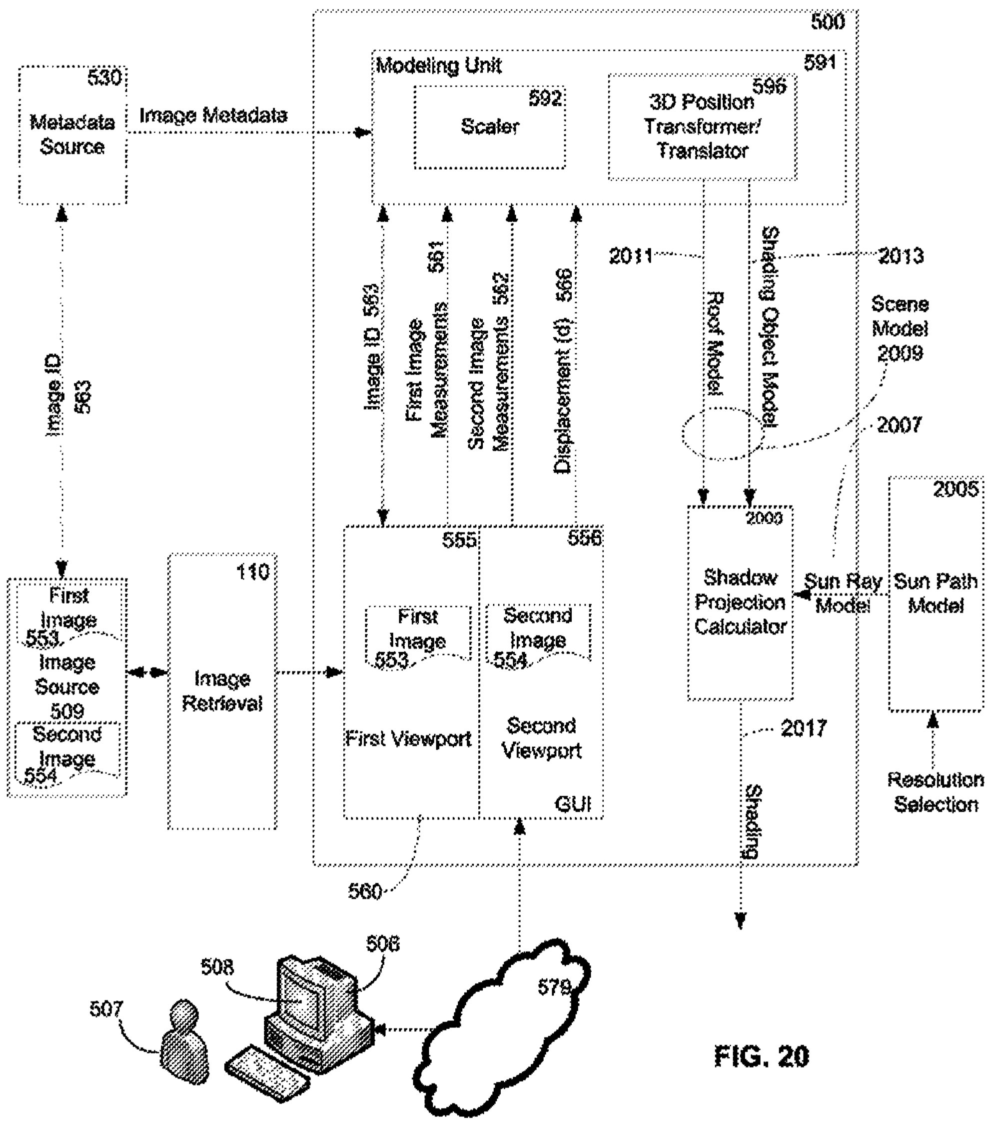
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First Image Measurements 561
Second Image Measurements 562
Displacement (d) 566
2011
Roof Model
Shading Object Model
2013
Scene Model 2009
2007
2005
2003
Shadow Projection Calculator
Sun Ray Model
Sun Path Model
First Image 553
Image Source 509
Second Image 554
110
Image Retrieval
555
556
First Image 553
Second Image 554
First Viewport
Second Viewport
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Shading
Resolution Selection
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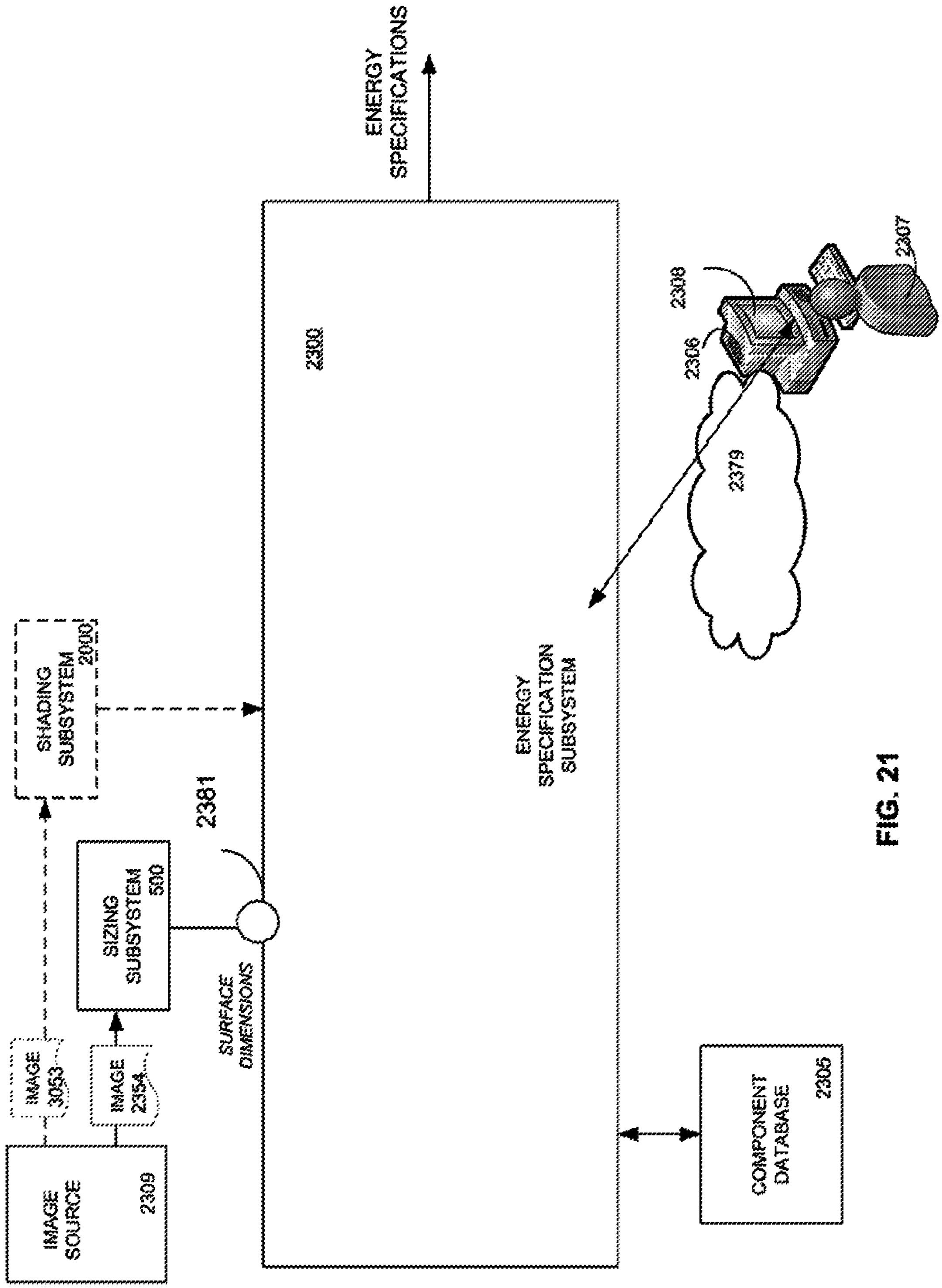
507
579

FIG. 20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ENERGY SPECIFICATION SUBSYSTEM
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2306
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SHADING SUBSYSTEM 2000
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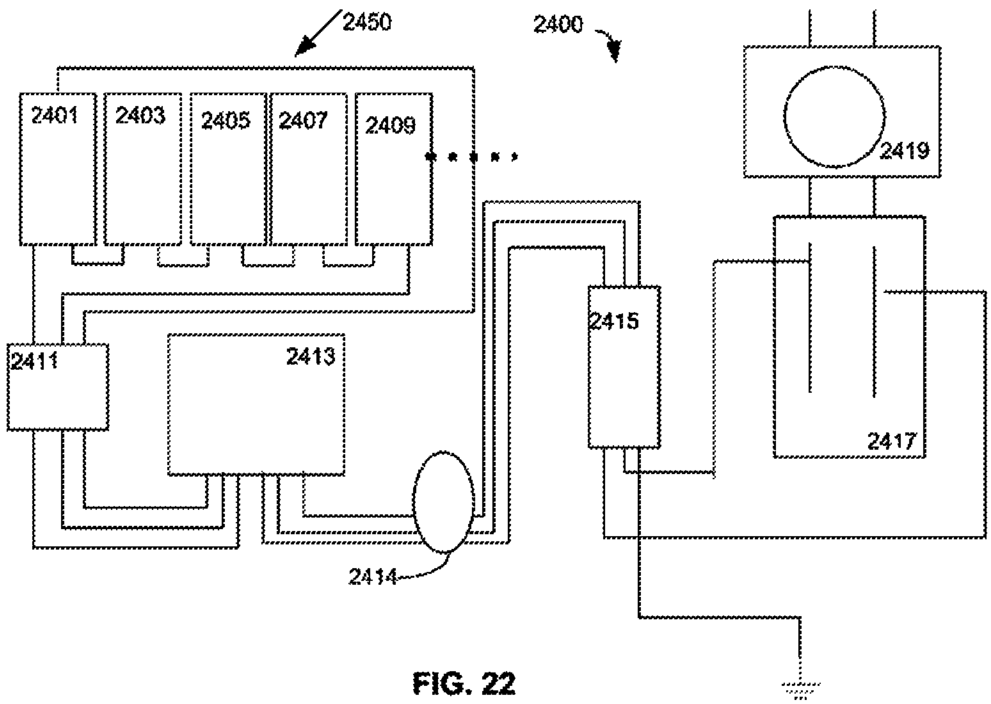
IMAGE 3053
IMAGE 2354
SURFACE DIMENSIONS
IMAGE SOURCE 2309
COMPONENT DATABASE 2305

FIG. 21



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2403
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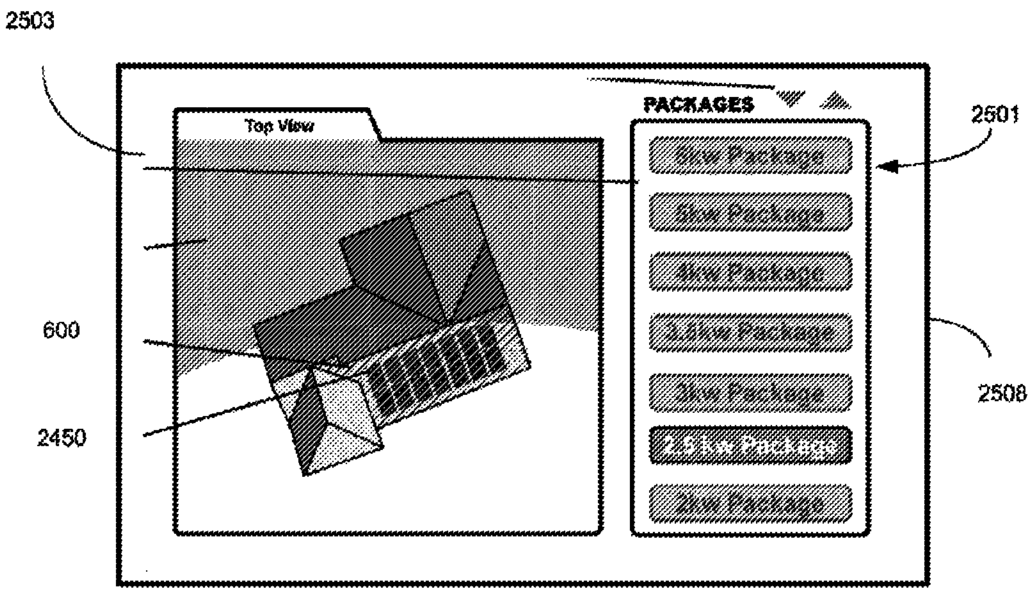
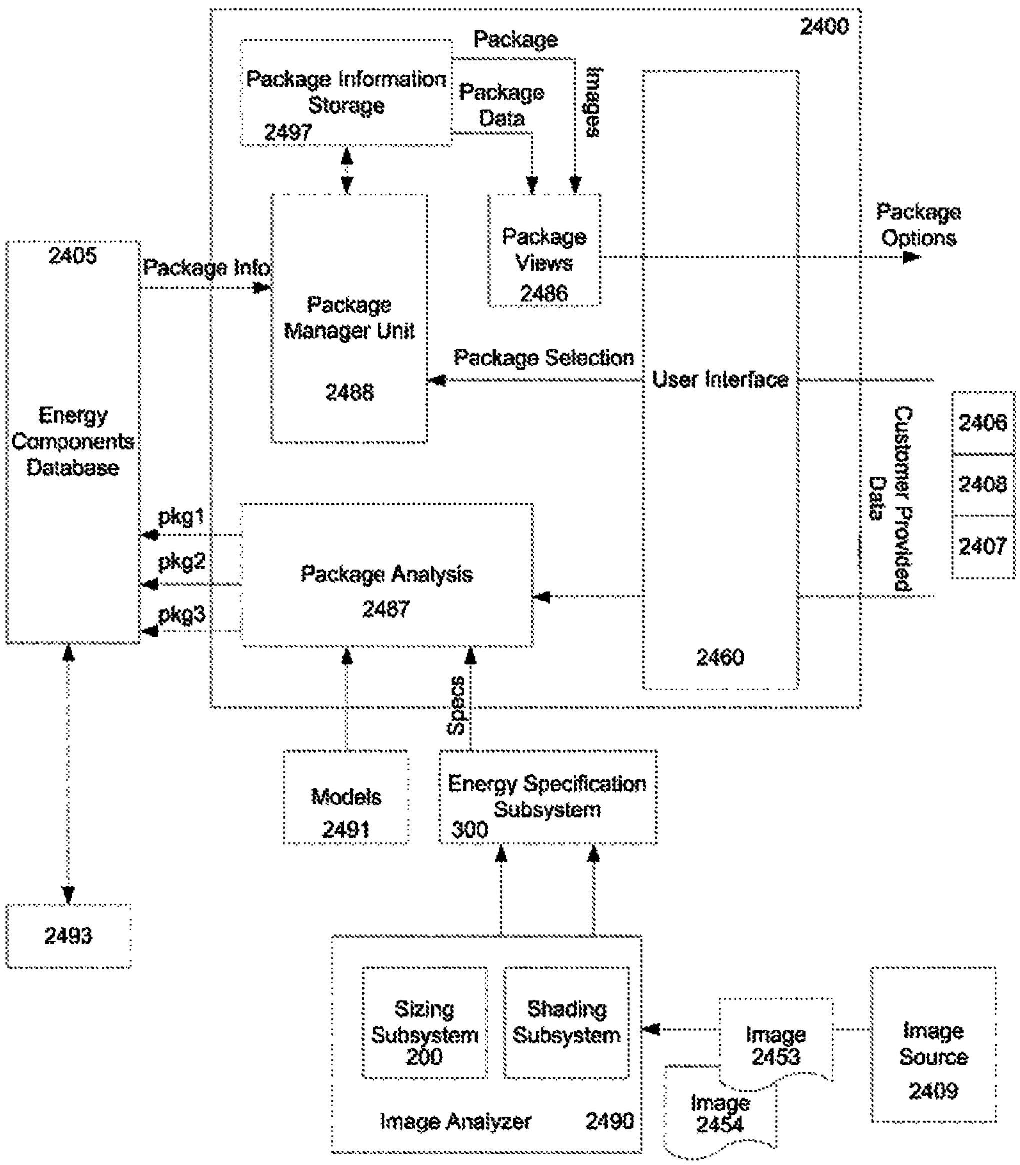
2411
2413
2417
2414

FIG. 22



2503
Top View
PACKAGES
6kw Package
5kw Package
4kw Package
3.5kw Package
3kw Package
2.5 kw Package
2kw Package
2501
600
2450
2508

FIG. 23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Package
Package Data
Images
Package Views 2486
Package Options
2405
Package Info
Package Manager Unit 2488
Package Selection
User Interface 2460
Energy Components Database
Customer Provided Data
2406
2408
2407
pkg1
pkg2
pkg3
Package Analysis 2487
Specs
Models 2491
Energy Specification Subsystem 300
2493
Sizing Subsystem 200
Shading Subsystem
Image Analyzer 2490
Image 2453
Image 2454
Image Source 2409

FIG. 24

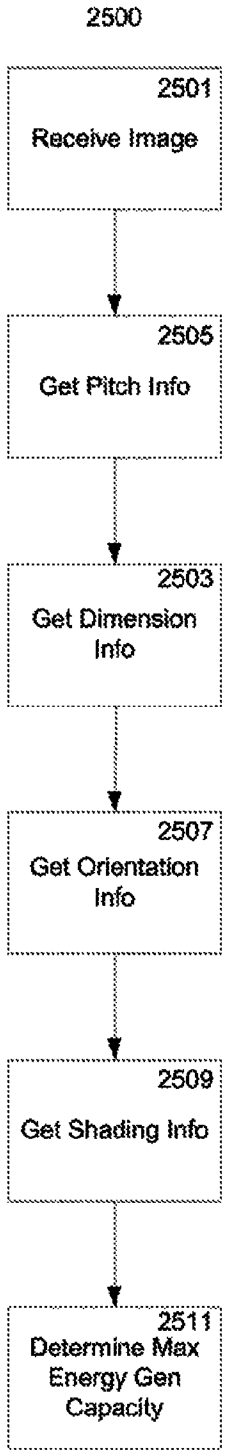
2500
2501
Receive Image
2505
Get Pitch Info
2503
Get Dimension Info
2507
Get Orientation Info
2509
Get Shading Info
2511
Determine Max Energy Gen Capacity

FIG. 25

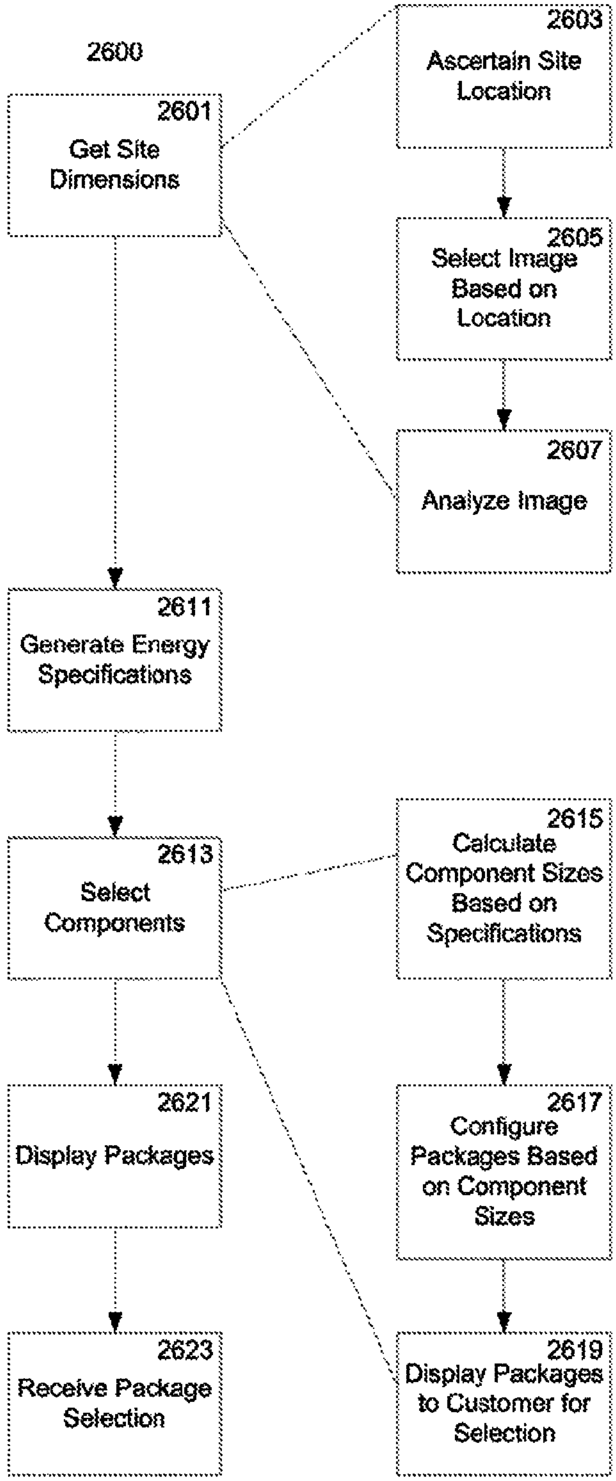
2600
2601
Get Site Dimensions
2603
Ascertain Site Location
2605
Select Image Based on Location
2607
Analyze Image
2611
Generate Energy Specifications
2613
Select Components
2615
Calculate Component Sizes Based on Specifications
2617
Configure Packages Based on Component Sizes
2619
Display Packages to Customer for Selection
2621
Display Packages
2623
Receive Package Selection

FIG. 26

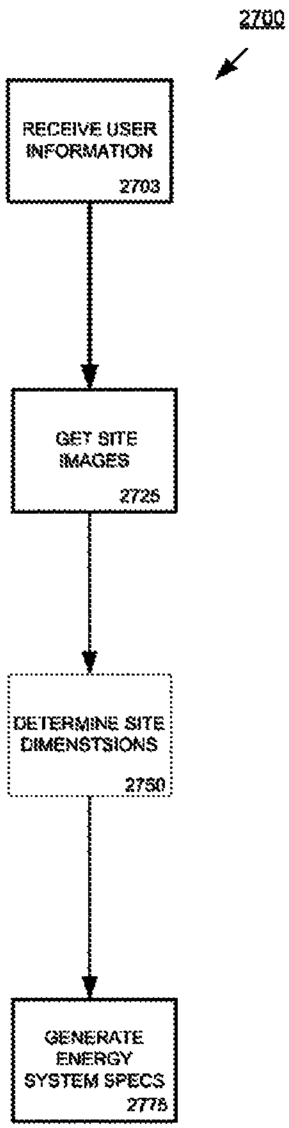

FIG. 27

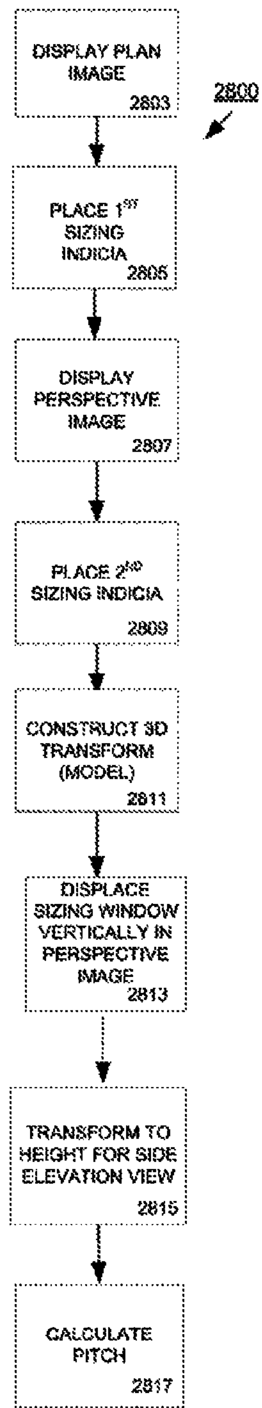

FIG. 28

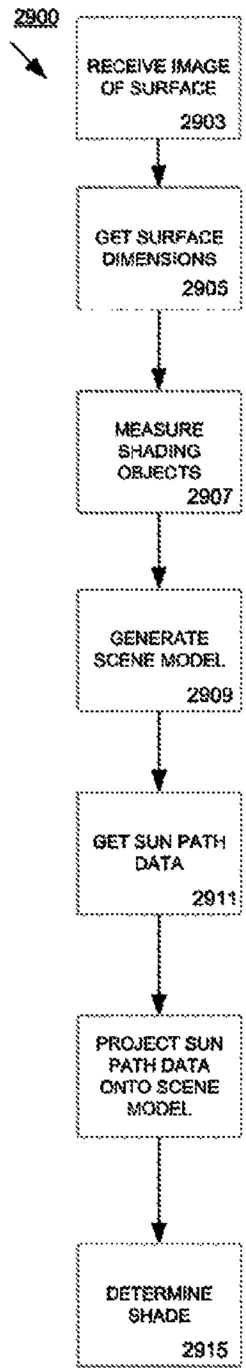

FIG. 29

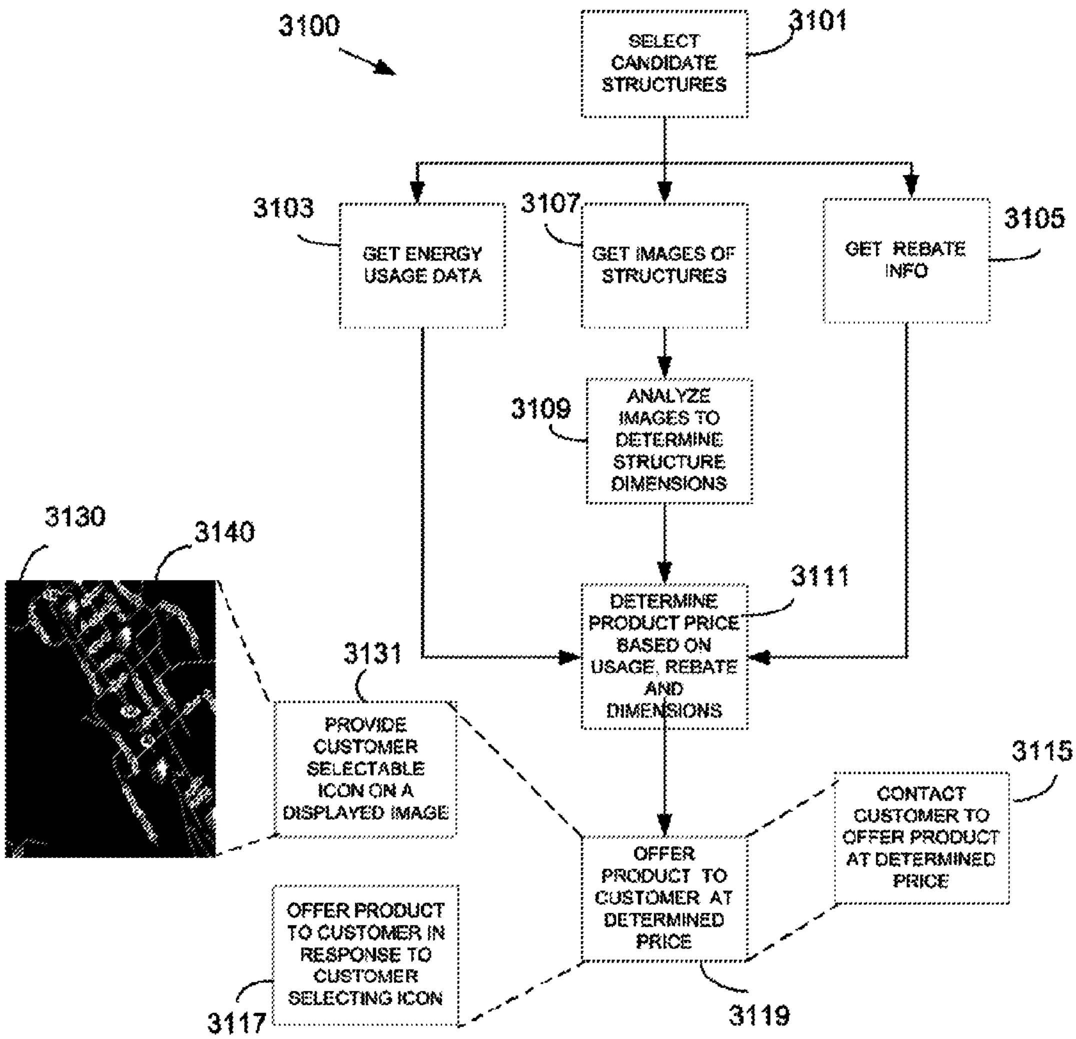
3100
SELECT CANDIDATE STRUCTURES
3101
3103
GET ENERGY USAGE DATA
3107
GET IMAGES OF STRUCTURES
GET REBATE INFO
3105
3109
ANALYZE IMAGES TO DETERMINE STRUCTURE DIMENSIONS
3130
3140
3111
DETERMINE PRODUCT PRICE BASED ON USAGE, REBATE AND DIMENSIONS
3131
PROVIDE CUSTOMER SELECTABLE ICON ON A DISPLAYED IMAGE
3115
CONTACT CUSTOMER TO OFFER PRODUCT AT DETERMINED PRICE
OFFER PRODUCT TO CUSTOMER AT DETERMINED PRICE
OFFER PRODUCT TO CUSTOMER IN RESPONSE TO CUSTOMER SELECTING ICON
3117
3119

FIG. 30

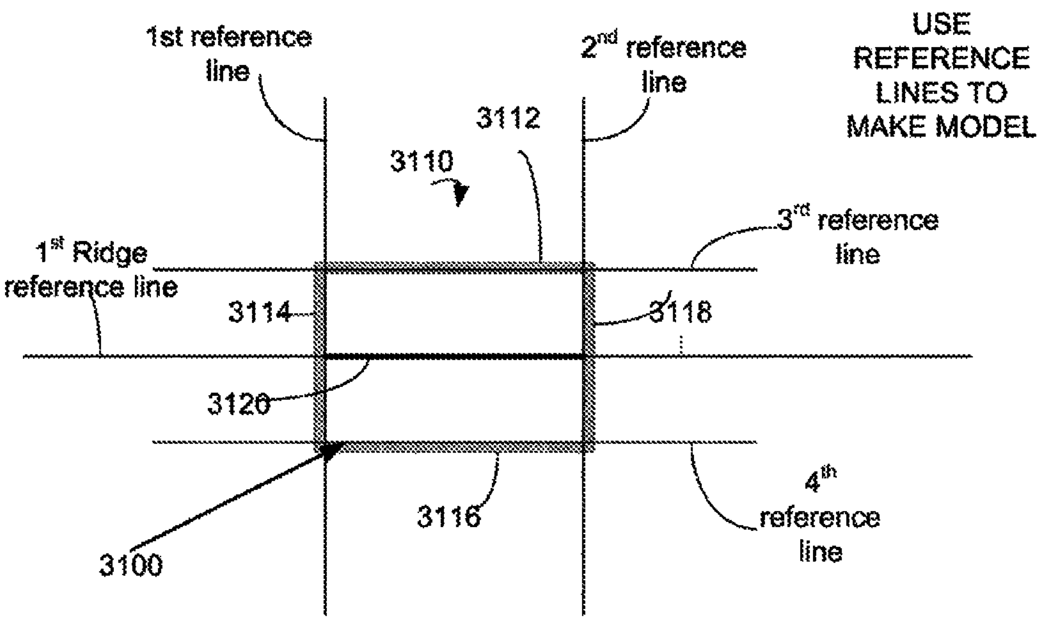
1st reference line
2nd reference line
USE REFERENCE LINES TO MAKE MODEL
3112
3110
3rd reference line
1st Ridge reference line
3114
3118
3120
3116
4th reference line
3100

FIG.32

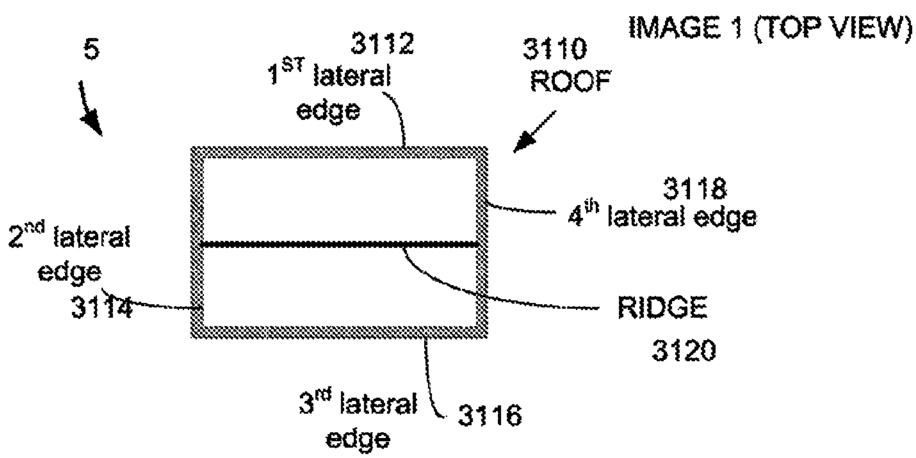
IMAGE 1 (TOP VIEW)
5
3112
1ST lateral edge
3110
ROOF
3118
4th lateral edge
2nd lateral edge
3114
RIDGE
3120
3rd lateral edge
3116

FIG. 31

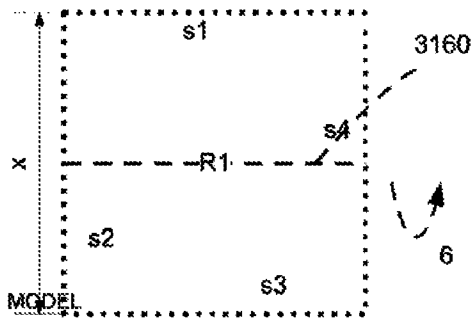
s1
3160
s4
x
R1
s2
s3
MODEL
6
100

FIG. 33

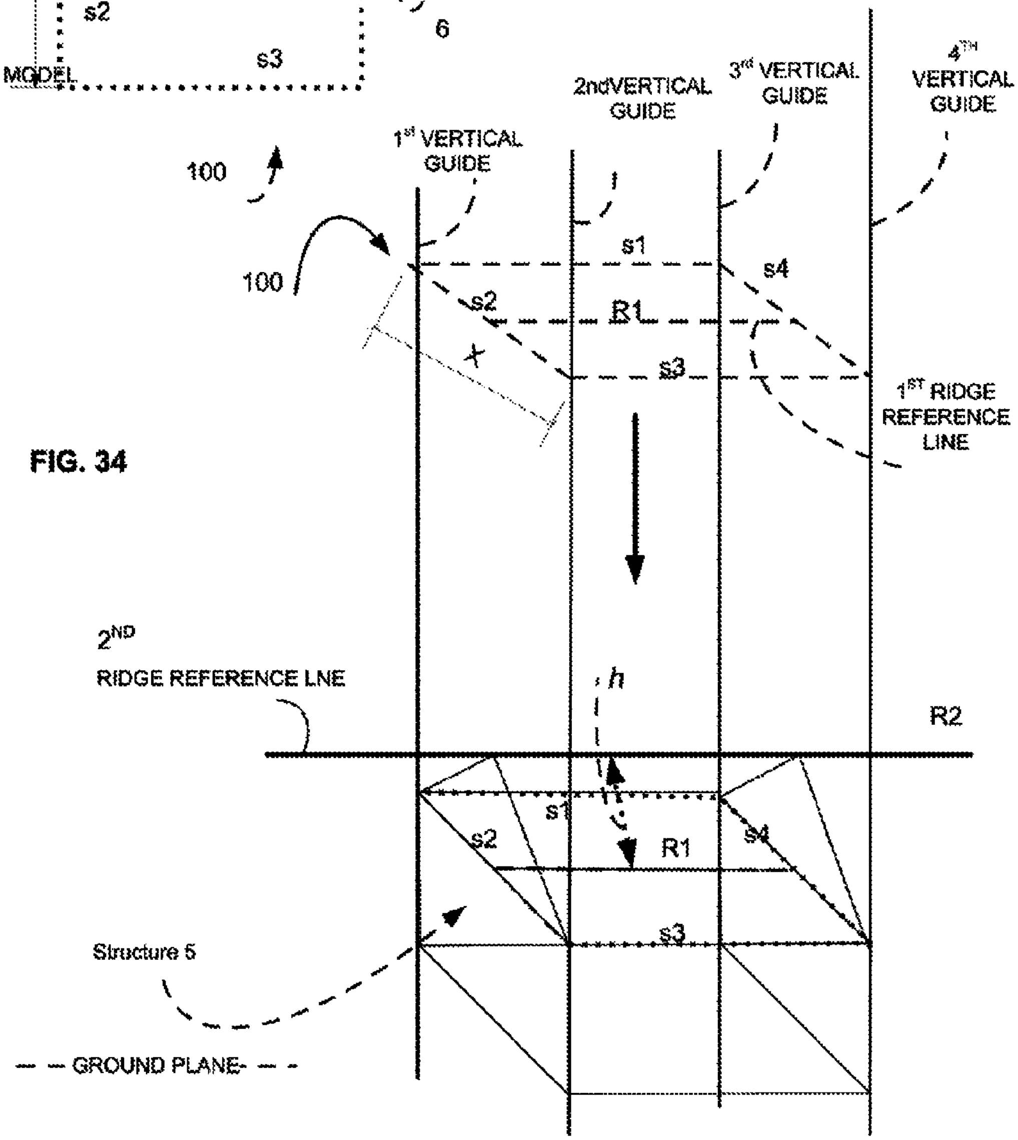
1st VERTICAL GUIDE
2ndVERTICAL GUIDE
3rd VERTICAL GUIDE
4TH VERTICAL GUIDE
100
s1
s4
s2
R1
x
s3
1ST RIDGE REFERENCE LINE
2ND RIDGE REFERENCE LNE
h
R2
s1
s2
R1
s4
s3
Structure 5
GROUND PLANE

FIG. 34

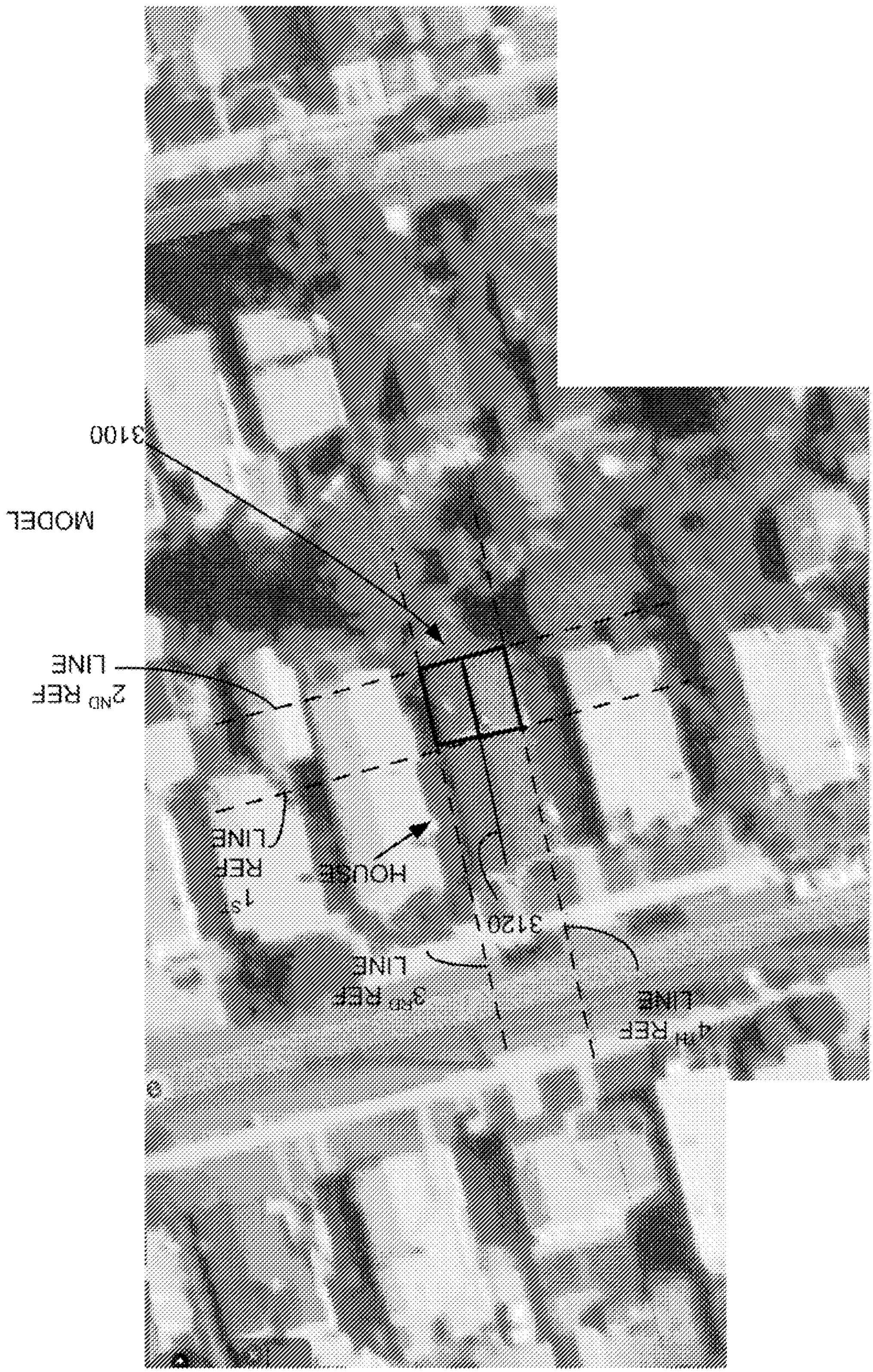
3100
MODEL
2ND REF LINE
1ST REF LINE
HOUSE
3120
3RD REF LINE
4TH REF LINE

FIG. 35

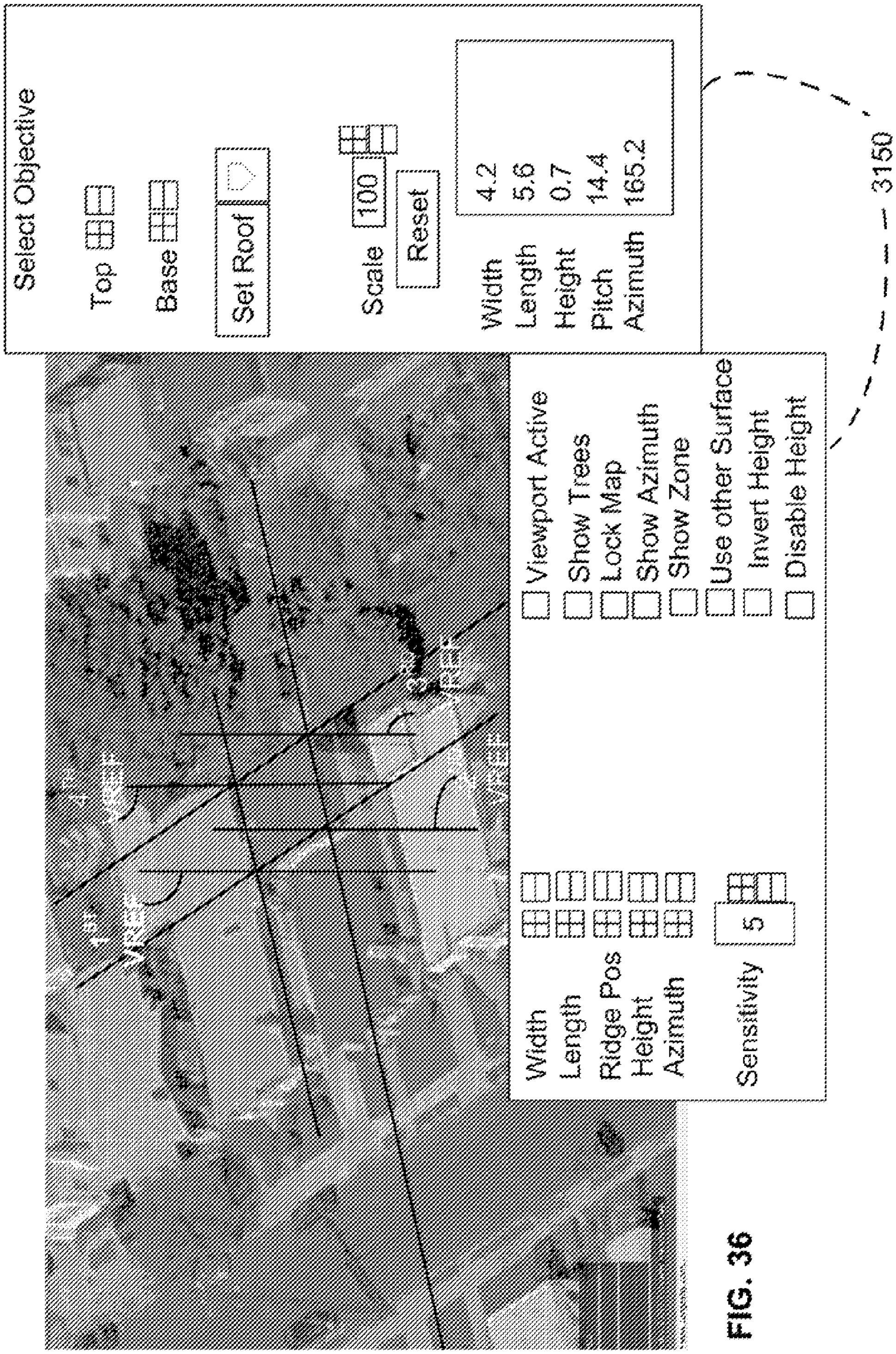
Select Objective
Top
Base
Set Roof
Scale
100
Reset
Width
Length
Height
Pitch
Azimuth
4.2
5.6
0.7
14.4
165.2
3150
Viewport Active
Show Trees
Lock Map
Show Azimuth
Show Zone
Use other Surface
Invert Height
Disable Height
Width
Length
Ridge Pos
Height
Azimuth
Sensitivity
5
VREF
VREF
VREF
VREF

FIG. 36

FIG. 37

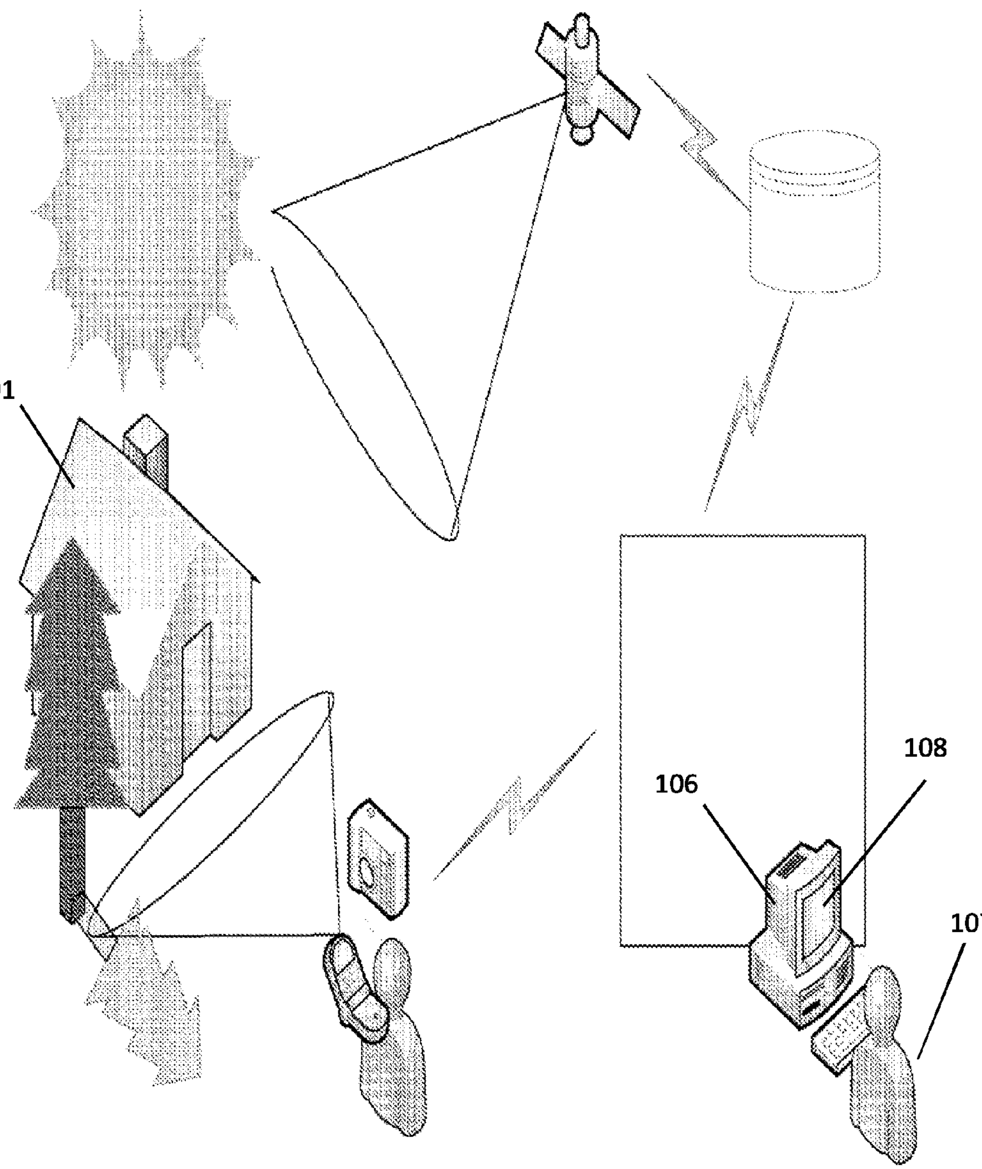

FIG. 38

METHODS AND SYSTEMS FOR PROVISIONING ENERGY SYSTEMS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of filing date of U.S. provisional application Ser. No. 61/025,431 titled "System and Method for Sizing a Roof for Installation of Solar Panels", naming the same inventors and filed on Feb. 1, 2008 in the USPTO, the specification of which is incorporated herein, in its entirety, by reference. This application claims the benefit of PCT/US08/79003 filed Oct. 6, 2008 in the PCT receiving office of the USPTO, naming the same inventors, the specification of which is hereby incorporated herein, in its entirety, by reference. This application claims benefit of filing date of U.S. provisional application Ser. No. 61/047,086 titled Customer Relationship Management Module, Marketing Module, Quick Sizing filed on Apr. 22, 2008 in the USPTO, naming the same inventors, the specification of which is incorporated herein, in its entirety, by reference.

FIELD OF THE INVENTION

The present invention relates generally to methods and systems for provisioning energy systems and in particular to methods and systems for provisioning solar energy systems.

BACKGROUND OF THE INVENTION

Environmental and cost concerns associated with traditional energy systems are increasing in today's energy conscious society. Concerns about oil and natural gas prices, and environmental concerns highlighted by recent hurricanes and other natural disasters have focused attention on alternative energy sources and systems.

So called 'clean energy' offers much hope for alleviating today's energy concerns. For example, today's solar technologies provide significant economic and environmental advantages for homeowners. Deployment of solar technologies is widely encouraged through financial incentives offered by local, regional as well as federal energy rebate programs.

Yet, despite these advantages and incentives many homeowners remain reluctant to convert from conventional fuel based systems to advanced solar and other alternative energy technologies. Part of the reluctance stems from the time, expertise and cost associated with converting from a conventional energy system to an alternative energy system such as a solar energy system. The current marketplace does not offer consumers sufficient information about costs and benefits of energy systems to allow a potential purchaser to make an informed choice when considering alternative energy systems.

For example, sizing a homeowner's particular roof-space including all the relevant features of that particular roof space typically requires an on-site visit by a technician. Further, it is presently not possible to remotely evaluate shading issues or other local factors that might impact the performance of a particular system. Nor is it possible for potential purchasers to visualize a system as it would appear installed on the purchaser's actual roof. As a result, information available to a purchaser about engineering requirements, aesthetic results, cost and environmental impact of a system considered for purchase is limited.

What are needed are systems and methods that provide consumers, contractors, third party vendors and others with

convenient, comprehensive and site-specific information for use in provisioning a site with a solar energy system. Further needed are systems and methods that provide a potential purchaser with site specific information related to energy system costs, benefits and aesthetics of alternative energy systems.

SUMMARY OF THE INVENTION

The invention provides consumers, private enterprises, government agencies, contractors and third party vendors with tools and resources for gathering site specific information related to purchase and installation of energy systems.

DESCRIPTION OF THE DRAWING FIGURES

These and other objects, features and advantages of the invention will be apparent from a consideration of the following detailed description of the invention considered in conjunction with the drawing figures, in which:

FIG. **1** is a high level block diagram illustrating a system for provisioning energy systems according to an embodiment of the invention;

FIG. **2** illustrates a Graphical User Interface (GUI) for displaying energy system information to a user.

FIG. **3** is GUI enabling a user to provide address information for an installation site.

FIG. **4** illustrates a display screen providing a graphical indication of energy savings and an image of a solar energy system installed on a user specified installation surface according to one embodiment of the invention.

FIG. **5** is a block diagram of a sizing subsystem according to an embodiment of the invention.

FIG. **6** is a perspective view illustrating dimensions of an example roof selected for installation of an energy system.

FIG. **7** is a top plan viewport of a roof installation surface illustrating placement of measurement indicia on a roof image according to an embodiment of the invention.

FIG. **8** is a top plan viewport of the installation surface illustrated in FIG. **7** viewed in a different orientation and including measurement indicia according to an embodiment of the invention.

FIG. **9** is a side elevation view of a structure including an installation surface comprising a roof according to one embodiment of the invention.

FIG. **10** illustrates a viewport displaying an image of an installation surface according to an embodiment of the invention.

FIG. **11** is a viewport displaying a top plan view of an installation surface and including a measuring tool according to an embodiment of the invention.

FIG. **12** is a viewport displaying a top plan view of the measuring tool illustrated in FIG. **11**.

FIG. **13** is a perspective view of the roof illustrated in FIG. **11**.

FIG. **14** is a top plan view of the roof illustrated in FIG. **11**.

FIG. **15** is a perspective view of the measurement tool illustrated in FIG. **11**.

FIGS. **16-19** illustrate positioning of the measuring tool of FIG. **11** with respect to the roof illustrated in FIG. **11** for various orientations of a roof image.

FIG. **20** is a block diagram of a sizing unit configured to provide shading information for an installation surface according to an embodiment of the invention.

FIG. **21** is a block diagram of an energy specification subsystem according to an embodiment of the invention.

FIG. **22** is a block diagram of an example solar energy system including system components according to an embodiment of the invention.

FIG. **23** illustrates a display screen providing an image of a user selected installation surface including an installed energy system and providing information related to the installed energy system.

FIG. **24** is a block diagram of a quote subsystem according to an embodiment of the invention.

FIG. **25** is a flowchart illustrating steps of a method for providing energy system specifications according to an embodiment of the invention.

FIG. **26** is a flowchart illustrating steps of a method for configuring component packages according to an embodiment of the invention.

FIG. **27** is a flowchart illustrating steps of a method for generating energy system specifications according to an embodiment of the invention.

FIG. **28** is a flowchart illustrating steps of a method for determining pitch according to an embodiment of the invention.

FIG. **29** is a flowchart illustrating steps of a method for determining shading for an installation surface according to an embodiment of the invention.

FIG. **30** is a flowchart illustrating steps of a method for providing quotes for energy systems according to an embodiment of the invention.

FIG. **31** is a top plan view of a house including a roof to be sized.

FIG. **32** illustrates reference lines positioned with respect to the roof illustrated in FIG. **1** for generating a model of the roof in accordance with an embodiment of the invention.

FIG. **33** illustrates a model defined by positioning the reference lines illustrated in FIG. **32** in accordance with an embodiment of the invention.

FIG. **34** illustrates a perspective view of a structure including a roof to be sized and further illustrating translation and rotation of the model of FIG. **3** to align the model to the perspective view of the same roof in accordance with an embodiment of the invention.

FIG. **35** illustrates a top plan view of a roof to be sized as the roof appears in an image obtained from a geographical information service (GIS) and further illustrating reference lines for generating a model in accordance with an embodiment of the invention.

FIG. **36** is a perspective view of the roof of the image of FIG. **35** and illustrating vertical reference lines in accordance with an embodiment of the invention.

FIG. **37** is a second perspective view of the roof illustrated in FIGS. **35** and **36**.

FIG. **38** Illustrates an information network, transmitting image data of a structure from a satellite through a GIS (geographical information service) and/or land based cameras to a central computer terminal.

DETAILED DESCRIPTION OF THE INVENTION—PROVISIONING SYSTEMS AND METHODS

Definitions

The term "PV cell" refers to a photovoltaic cell, also referred to as solar cell.

The terms "PV Module" and "solar panel" and 'solar tile' refer to various arrangements of interconnected assemblies of photovoltaic cells.

The term "PV Array" refers to a plurality of interconnected solar panels or tiles.

The term 'provisioning' refers to providing, supplying, equipping, installing, or preparing to provide, supply, equip or install energy systems and energy system components for delivering energy to a site.

FIG. **1** Provisioning System

FIG. **1** illustrates a provisioning system **100** according to an embodiment of the invention. System **100** and methods of the invention will find application in provisioning energy systems, for example, solar energy systems and other alternative energy systems. Solar energy systems include off-grid systems and grid tie systems. Off grid systems include standalone systems designed for homes, recreational vehicles, cabins, and backup and portable power applications. Systems and methods of the invention are also suitable for provisioning grid-tie systems. Further embodiments of the invention are suitable for provisioning hybrid off-grid systems, including systems integrating gasoline, propane or diesel generator power sources with other energy systems.

System **100** enables a user, for example user **107**, to undertake efficient, cost effective and accurate execution of numerous phases of an energy system provisioning processes without the need for visits to the site to be provisioned. For example system **100** provides a tool for measuring a user selected roof or other user-selected other installation surface. One embodiment of the invention provides a sizing system for determining solar photovoltaic (PV) potential of a user selected installation site. System **100** matches user selected roof space and energy needs to commercially available system components without the need for visits to the user selected installation site by a technician or engineer.

System **100** comprises a graphical user interface module **200** and at least one of an energy specification subsystem **3000**, a sizing subsystem **500** including a pitch calculator **594**, a shading subsystem **2000**, an image retrieval subsystem **110** and a package assembly subsystem **3100**. Various embodiments of system **100** are configured to further communicate with at least one of a plurality of energy system related databases, for example, contractor database **113**, customer database **103**, energy components database **105**, metadata source **130**, residential energy consumption information database **117**, energy rebate program information database **115** and residential building code database **111**.

Embodiments of system **100** as disclosed and enabled herein are implementable using commercially available hardware. For example a commercially available processor or computer system adapted in accordance with the teachings herein implements system **100** including at least one of subsystems **110**, **2000**, **3000**, **3100**, **500** and/or **200**. For example, one of ordinary skill in the art will recognize upon reading this specification, that commercially available processors, memory modules, input/output ports and other commercially available hardware components are suitable for use in constructing embodiments of system **100**. These may be assembled as taught in this specification to arrive at the various embodiments.

Further, the teachings contained in this specification are implementable in a variety of combinations of hardware and software components. Where appropriate, flowcharts and detailed descriptions are provided herein to enable one of ordinary skill in the art to implement the features and functions of embodiments of the invention. In addition, some embodiments of the invention are configured for communication between system **100** and databases **111-130** via wired or wireless Internet or other network communication links. Other embodiments of the invention are configured for wireless or wired internet communication between subsystems of system **100**.

Graphical User Interface (GUI) **200**

System **100** implements a graphical user interface unit **200** (GUI unit) that enables a user **107** to interact with system **100** and its subsystems. According to some embodiments of the invention GUI **200** is implemented by a server providing a website and serving interactive web pages for gathering information and providing calculation results, images and other energy system information to user **107**.

FIGS. **2** and **3** illustrate examples of an information presentation GUI **2000** and an information gathering GUI **380**, respectively. GUIs **2000** and **380** are generated by GUI unit **200** for presentation on a display device **108** of a user system **106** (best illustrated in FIG. **1**). For example, display device **108** displays GUI **380** to user **107**. At least a portion **381** of display screen **380** is configured to receive user information, for example, site location information from user **107**. User **107** provides the information by entering the information via, for example, a keyboard of system **106**.

System **100** receives user provided information related to location of a site to be provisioned with solar energy capability. GUI **200** provides the received user information to an image retrieval subsystem of system **100**. According to the embodiment illustrated in FIG. **1**, GUI **200** provides the received user information to a sizing subsystem **500** of system **100**. Sizing subsystem **500**, in turn provides the information to image retrieval subsystem **110**.

In alternative embodiments of the invention, location information received from user system **106** is provided directly to image retrieval subsystem **110**. In either configuration, system **100** uses the location information received from user system **106** to retrieve an image **153** of the location (or site) from a geophysical database **109**. In response to receiving the location information, system **100** provides an image corresponding to the location, for example an image of a roof of a house **391** for display on screen **380** of display device **108** of a user system **106**.

Embodiments of system **100** enable a user **107** to interact with system **100** to determine, at least partly automatically, information related to size of an installation area of a site. FIG. **2** illustrates a GUI **381** as displayed on a display screen **380** of a display device **108** of a user system **106**. GUI **381** enables user **107** to provide location information, for example, address **393** of a user-selected site via user system **106**. The information is transmitted via a communications link, for example the Internet **107** and received by system **100**. In response to receiving the location information, system **100** retrieves an image of the location from a source of images such as geophysical database **109**. System **100** provides a retrieved image **153** of the user selected site based on the location information provided by the user.

In one embodiment of the invention, a graphical user interface (best illustrated in FIGS. **8-9**) cooperates with sizing subsystem **500** of system **100** to implement a sizing tool enabling user **107** to determine surface dimensions and pitch of a surface, for example a roof **191** of a house appearing in the retrieved image **153**. Thus there is no need to physically visit the installation site to make measurements and perform sizing calculations.

Image Retrieval Subsystem **110**

Returning now to FIG. **1** an image retrieval subsystem **110** communicates with a source of images **109**. As used herein the term 'images' refers to photographic images and also to data and electrical signals representing photographic image information. The term 'images' also refers to data comprising other types of images such as still video images, video frames and fields of motion video images. A variety of image types and formats are suitable for use in system **100**. Suitable image

formats include standard file formats containing satellite or aerial photography (such as JPG, GIF, PNG etc) and also images served through a tile-server, whereby a single image is broken into multiple tiles which are joined to form the full image. Furthermore, these images may also be generated from other data sources, such as vector shapes, 3D (CAD) files and others rather than satellite or aerial photography.

In one embodiment of the invention more than one source of images is provided to system **100** and used to determine roof size and pitch. For example, in one embodiment of the invention user **107** employs an image capture device embedded in, for example, a cellular telephone, to capture an image of roof **191**. The image captured by the image capture device is then transmitted by user **107** to system **100** via Internet **179**, or via cellular, satellite, radio frequency or other transmission means. In that case, system **100** determines at least one of roof size, pitch and shading based in part on the user-captured image and at least in part on at least one image retrieved from an image database such as geophysical database **109**.

In one embodiment of the invention source of images **109** comprises a geographical image database providing, for example, images **153** and **154**. In one embodiment of the invention images **153** and **154** comprise digital data corresponding to images comprising satellite photographs. In some embodiments of the invention images **153** and **154** comprise images uploaded to source **109** by a third party, for example, a homeowner, a site manager, and images otherwise provided to source **109** by a user of system **100**. In other embodiments of the invention, sources of images **109** include locally stored images.

In one embodiment of the invention images of geographic regions comprising potential sites to be provisioned with an energy system are obtained, for example, by satellite or aerial photography. The images are coded using image geo-coding software and stored in a memory, for example geographical database **109**. Geo coding refers to a process of finding associated geographic coordinates (typically expressed as latitude and longitude) from other geographic data, such as street addresses, or zip codes. With geographic coordinates the features can be mapped and entered into Geographic Information Systems, or the coordinates can be embedded into media such as digital photographs via geo tagging.

Reverse Geo coding refers to finding an associated textual location such as a street address, based on geographic coordinates. A geo coder is software or a (web) service that implements this process. Some embodiments of the invention rely on a reverse geo coder to obtaining site addresses based on geographic coordinates. The geographic coordinates are determined, for example, by examining geo coded images including sites of interest for provisioning energy systems. One embodiment of the invention employs a Geographic Information Service (GIS) such as Google Earth™ comprising image source **109**.

In one example embodiment of the invention image source **109** includes an image of a site considered for provisioning with an energy system wherein the site comprises at least one building structure, e.g., a house. The at least one image of the site represents a plan view, for example a top or bottom plan view, of a roof of the building. In some embodiments of the invention image source **109** includes at least one perspective image of a roof for installation of a solar energy system. In an example embodiment image retrieval subsystem **110** is configured to receive a first image **153** comprising a plan view of the roof and a second image **154** comprising a perspective view of the roof.

Sizing Subsystem **500**—Pitch Calculator **594**

System **100** includes a sizing subsystem **500** including a pitch calculator **594**. Sizing subsystem **500** is coupled for communication with image retrieval subsystem **110** and GUI **200**. Image retrieval subsystem **110** is coupled for communication, for example, via the Internet **179**, with a least one source of images **109**. Image retrieval module **110** is configured to provide at least one image **153** of a site to be provisioned.

GUI **200** cooperates with sizing subsystem **500** to implement a sizing tool enabling user **107** to determine surface dimensions and pitch of a surface without the need to physically visit the installation site to make measurements and perform sizing calculations. In response to receiving user information data, geophysical data including at least one image is downloaded from a source of geophysical data **109**. The downloaded geophysical information is selected based on information provided by the user. For example, in the case wherein user **107** is a customer considering purchase of an energy system, user-provided information includes, for example, an address of a home to be provisioned with an energy system. In that case, an image of the user's home, including a view of the user's roof is downloaded from source of images **109**. In one embodiment of the invention system **100** provides at least a portion of the downloaded image for display to user **107** on a display device **108** of a user's system **106**.

User **107** interacts with system **100** and sizing subsystem **500** via GUI **200** to measure portions installation areas included in displayed images. The measurements are provided to a pitch calculator **294**. Pitch calculator **294** determines pitch of a surface, for example, roof pitch, based on the image measurements made by user **107**. Alternative embodiments of the invention determine pitch of other installation surfaces, for example, installation platforms not associated with a building and ground based installation surfaces based on measurements made automatically by sizing subsystem **500**.

Shading Subsystem **2000**

In one embodiment of the invention image retrieval subsystem **110** provides at least one downloaded image **153**, **154** to shading subsystem **2000**. In one embodiment of the invention shading subsystem **2000** communicates with user system **106** via GUI **200** to enable user **107** to interact with the downloaded image to identify shading objects impacting sun access of an installation surface. In other embodiments of the invention user interaction is not relied upon to identify shading objects. Instead, system **100** implements image analysis techniques to identify shadows in an image and to generate shading data based on the shadow information in the image.

Energy Specification Subsystem

An energy specification subsystem **3000** is coupled for communication with sizing subsystem **200**. In some embodiments of the invention energy specification subsystem **3000** is further coupled for communication with shading subsystem **500**. Energy specification subsystem **3000** receives sizing information from sizing subsystem **500**. In some embodiments of the invention energy specification subsystem **3000** receives shading information from shading subsystem **2000**. Energy specification subsystem provides energy system specifications for a site represented in a downloaded image based on the sizing and shade information.

In some embodiments of the invention, energy specification subsystem **300** is coupled for communication with a package assembly module **400**. Package assembly module **400** is coupled for communication with a source of energy system component information, for example, an energy components database **105**.

Package Assembly Module **3100**

Package assembly module **3100** is configured to communicate with at least one of a component database **105** and a rebate program database **115**. Package assembly module includes calculator module (not shown). Package assembly module generates at least one package comprising solar energy components suitable for installation at the consumer's site. To do this, package assembly module evaluates at least some of the following information: information about energy to be supplied by a solar energy system provided by sizing module **500**; results of roof pitch, roof area, shading and other calculations.

Package assembly module **3100** communicates with component database **105** to determine suitable component selections to comprise package offerings for the consumer. Package assembly module obtains information about component prices and availability from database **105**. Based on this information package assembly module **3100** generates at least one package comprising suitable components for a solar energy system for the consumer's site. Information about the package, including price information, is provided by package assembly module **3100** to consumer system **106** via user interface module **200**. The information is displayed on a consumer display **106** to allow the consumer to select a package for purchase. Package assembly module receives the consumer's package selection.

External Databases

System **100** comprises system interfaces for communicating with external databases and sources of information relating to energy systems. For example, embodiments of the invention are configured to communicate with and receive data from geophysical database **109**, residential energy consumption database **117**, energy rebate database **115** and building code database **111**

Some embodiments of the invention include a contractor database **113**. In that case, contractor database **113** stores information, including for example, contractor location, qualifications, availability etc. related to contractors and installation support personnel. In that manner some embodiments of system **100** enable a user **107** to interact with GUI **200** to select a contractor to install an energy system procured using system **100**. According to an embodiment of the invention solar energy system installers, for example, electricians or electrical contractors are provided with on line training in sales, customer service and system maintenance. Some embodiments of the invention include a capability to automatically dispatch trained installers and sales personnel to customer's homes when a customer requests a face-to-face discussion.

After an installation is completed, some embodiments of systems and methods of the invention store a customer's information in customer database **103**. According to some embodiments of the invention an internet connection to a wireless output of a customer's energy inverter (for example equipped with a meter) will gather, analyze and display an installed energy system output and savings (financial and environmental). According to some embodiments of the invention recurring and on-demand site visits are automatically scheduled to maintain, clean and service a customer's system after an installation.

Information related to rebates for using alternative energy platforms is provided by energy rebate program database **115**.

In that case system **100** communicates with database **115** to factor financial incentives into cost calculations for a specific user selected site.

Thereby embodiments of the invention provide direct selling, remote automatic sizing and delivery of energy systems. The invention further provides methods that decrease the cost and increase the ease by which customers' access energy system information.

FIG. **27** is a flowchart illustrating steps of a method for provisioning energy systems according to an embodiment of the invention. At step **2703** Information about a site to be provisioned is received. In one embodiment of the invention a user, for example, a potential purchaser of an energy system, accesses a website implementing a system and method of the invention using, for example, a personal computer. A webpage of the website prompts the user to provide information to be used for provisioning a solar energy system to the user.

In one embodiment of the invention information about a site is received from a user, for example a homeowner, who may be considering installation of a solar energy system on a roof of a home. In other embodiments of the invention information about a site to be provisioned is provided by a vendor, an agent a commercial planner or other party desiring information about energy systems for a site. Examples of information received at step **2703** for a user/homeowner include such data as zip code, age of the home, square footage of the home, number of occupants and energy bill totals for a consecutive 12-month period. Various embodiments of systems and methods of the invention use this information, at least in part, to determine energy requirements of a home.

In response to receiving the user information data, geophysical data is downloaded from a source of geophysical data at step **2725**. The downloaded geophysical information is determined based on the information provided by the customer. The geophysical information includes, for example, an image of the customer's residence including a view of the customer's roof. In one embodiment of the invention the customer is shown an image of their own home. In one embodiment of the invention the image is obtained using satellite image geo-coding software. One embodiment of the invention employs a GIS service (for example Google Earth) to obtain images to locate and view properties. In some embodiments of the invention, only one image is retrieved from a source of images. In other embodiments of the invention, for example, for embodiments relying on 3-dimensional models, more than one image is retrieved from a source of images. In other embodiments of the invention, site images are accessed without the need to download images from a source of images. For example, images are rendered on a display device of a computer system of a user.

Site dimensions are determined at step **2750**. Examples of site dimensions include surface geometry, for example, the shape and area of a rooftop. In some embodiments site dimensions include pitch of a surface, for example, pitch of a roof. The site dimensions are determined by analyzing the images obtained in step **2725**. In one embodiment of the invention the site dimensions are automatically determined by analyzing the images accessed at step **2725**. In other embodiments of the invention site dimensions are determined or provided by a user. The site dimensions are used to generate energy system specifications for the installation site at step **2775**.

FIG. **5** Sizing Subsystem **500**

First Embodiment

The term 'sizing' as used herein refers to obtaining or generating length and width measurements for a generally

rectangular planar installation surface such as a side of a roof. An installation surface is a surface area of a roof, for example a roof side contemplated for installation of energy system components. According to some embodiments of the invention, sizing of an installation surface is carried out by a sizing subsystem **500** automatically or at least partly automatically by means of user interaction with a GUI **560** of system **500**.

FIG. **5** illustrates a remote sizing subsystem **500** according to an embodiment of the invention. Subsystem **500** includes a graphical user interface **560** configured for communication with a computer system **506** accessible by a user **507**. GUI **560** is further configured for communication with an image retrieval subsystem such as subsystem **110** illustrated in FIG. **1**. GUI **560** provides images for display on display device **508** of user system **506**. By interacting with the displayed images, user **507** generates measurements **504** which are provided to a modeling unit **591**.

Once an image of an installation surface is downloaded to system **100** a sizing subsystem **500** is deployed to measure the installation surface. In one embodiment of the invention, dimensions of an installation surface, for example, a roof area, are determined by superimposing images representing differing views of the roof surface. For example, at least two images representing different views of the surface are provided and displayed to a user via a graphical user interface. As illustrated in FIG. **5** a first image of the surface to be sized is displayed to the user via a viewport **555**. A second image of the same surface to be sized is displayed to the user via a second viewport **556**. In one embodiment of the invention, GUI **560** is configured to enable user **507** to manipulated images **553** and **554** such that one image is superimposed on the other. GUI **560** determines dimensions of the surface being measured by vector evaluation of image displacement.

In one embodiment of the invention, GUI **560** implements a sizing tool (examples illustrated in FIGS. **8-14**.) The sizing tool is configured for interaction with user system **506** via a mouse, keyboard, cursor, trackball or other means such that user **507** is enabled to manipulate the sizing tool with respect to the images displayed in viewports **555** and **556**. In that manner GUI **560** enables user **507** to measure dimensions of a surface appearing in images **553** and **554**. GUI **560** records the measurements. In one embodiment of the invention, the recorded measurements are used to determine a configuration of solar panels suitable for installation on the surface, based on the measurements of the surface area and, in some embodiments, surface pitch.

According to one embodiment of the invention the shape of an installation surface is determined by plotting the perimeter of the installable area in a first view comprising a 2d representation of the installable area. The intersection of the plotted points with the plane of the installation surface determines the 3-dimensional installation surface perimeter.

FIGS. **6** and **9** illustrate respectively a perspective view and a side elevation view of a "real world" surface to be measured wherein the surface comprises a roof **600**. Roof **600** is defined by roof side surfaces **640** and **641** (**641** not visible in FIG. **6**). As seen in FIG. **6** roof surface **640** is defined by parallel side edges **631** and **731** and parallel side edges **630** and **730**. Roof side surfaces **640** and **641** meet to form a roof ridge **641**. Roof ridge **641** is elevated with respect to a bottom side surface edge **630**. The elevation of roof ridge **641** with respect to bottom edge **630** is represented by dimension H. A roof span of **600** is indicated as B. Roof **600** is oriented in FIG. **6** as indicated by axes **670**. In FIG. **9** orientation of roof **600** is indicated at **970**.

FIG. **10** illustrates a GUI **1000** enabling a user to measure portions of a surface to be sized, for example, portions of roof

600, illustrated in FIG. **6**. In one embodiment of the invention, as illustrated by FIG. **10**, an instructional video clip **1003** is displayed on a portion of the user's screen to assist user **507** in interaction with GUI **560**. GUI **560** enables measurements of a surface such as a roof **600** to be determined by carrying out measurements on an image of the roof **600**.

In one embodiment of the invention, a viewport **1000** displays an image in which a structure to be sized appears, for example, a house including a roof **600**. In some cases an image presented in viewport **1000** will include roof **600** along with neighboring structures, for example, houses **1002** and **1004**. In that case GUI **560** (FIG. **5**) is configured to provide a marker, for example cross hair marker **1010**. Marker **1010** is movable by user **507** via a mouse, trackball, or the like. In that manner user **507** is enabled to select, or indicate, a house, or a roof portion, to be sized by positioning marker **1010** over the image portion the user wishes to select.

A viewport **1000** is provided by GUI **560** (example first viewport illustrated in FIG. **5** at **555**). In the embodiment illustrated in FIG. **10** system **500** provides a flat image of a roof which is, in real life, a three dimensional shape. As illustrated in FIG. **10** a surface area **1010** representing an installation surface is selectable by user **507** for sizing. As explained in more detail with respect to FIGS. **11-19**, a user selects points on the image in the first viewport to define an installation surface.

Returning now to FIG. **5**, the selected points are provided to modeling unit **591**. Modeling unit **591** develops a description of the three dimensional roof shape based on two dimensional descriptions received from user system **506**. In some embodiments of the invention, modeling unit **591** also receives image metadata for the image in viewport **1000**. The image metadata is provided, for example, by a metadata source **530**. System **500** uses the metadata to develop the three dimensional description of the roof **600**. Image metadata includes, for example, image scale information for a displayed image. In one embodiment of the invention the scale information is used to determine a 'real world' size of roof **600** based, in part on roof dimensions measured on an image, and in part on metadata associated with the image.

In some embodiments of the invention metadata includes information such as latitude/longitude, altitude, position of camera, camera focal length etc. Meta data may be stored in the image itself for example, data stored in an image file, but not visible in the displayed image. In other embodiments of the invention, metadata is provided by a separate metadata data source **530**. Metadata is cross referenced to a corresponding image, for example by image ID as indicated at **563**.

In determining length and width of an image of a surface, sizing subsystem **500** cooperates with a modeling subsystem **591**. Modeling subsystem **591** comprises a 3D transform/translation module **596** and a scaler **592**. Image transform module **596** generates a transform, or map, for points on a user measured surface. The transform maps points defining the surface shape in one orientation with respect to a reference axis to corresponding points defining the surface shape in any other orientation with respect to the reference axis. Once a transform is generated, points defining a surface shape in, e.g., a perspective view are translatable to corresponding points comprising a side elevation model description of the shape.

FIG. **9** illustrates a side elevation view of the house **600** illustrated in FIG. **6**. A side elevation description includes displacement information, e.g., relative height information. Relative height information is significant, for example, in determining a relative height of a roof ridge with respect to the roof base. Once the relative height is determined, pitch of a roof side is calculated using the height information and width information obtained during sizing.

For example, pitch of a roof **640**, is given by rise (H)/run (B**1**). In one embodiment of the invention, run is estimated by determining the horizontal distance between a gutter edge **903** and roof ridge **641**. Then the elevation (rise) of the ridge **641** above the gutter edge **903** is determined as indicated at H. Once horizontal distance (run) and elevation (rise) are determined, roof angle, and thus pitch, is calculated by pitch calculator **504**. Therefore a homeowner need not manually measure a 'real life' roof in order to determine appropriate components sizes for an energy system to be installed on the roof.

Modeling unit **591** translates the points defining the shape in the viewed orientation of the displayed image to points defining the shape in a side elevation view, for example, as illustrated in FIG. **9**. Points defining the shape in the side elevation view provide a scaled real world relative elevation of, for example, a roof ridge **641** with respect to a roof base **635**.

Modeling unit **591** is coupled to a pitch calculator **594** to provide a displacement measurement H. For example, a displacement measurement H comprises a measure of z axis displacement of a roof ridge relative to a roof base for a roof base orientation along an x-y axis. Pitch calculator **594** provides pitch information, e.g., pitch of a roof based on the displacement and base information.

Thus sizing subsystem **500** is capable of determining height, width and pitch of an installation without the need for specific views, for example a plan view and an elevation view of a roof surface.

As illustrated in FIG. **5** GUI **560** provides viewports **555** and **556**. Viewports **555** and **556** enable user **507** to view 2 dimensional representations, for example 1^{st} and 2^{nd} images **553** and **554**, of a three dimensional scene. FIG. **7** illustrates an example viewport **700** displaying a first image of roof **600**. Roof **600** is displayed to user **507** on a portion of display device **508** (illustrated in FIG. **5**). A surface **640** of roof **600** under consideration for installation of an energy system is displayed within viewport **700**. A roof **600** is displayed in viewport **700** at a first orientation with respect to a 3D axis **770**. User **507** operates a mouse, trackball, keyboard or other input/output device coupled to user system **506** to interact with the image in viewport **700**. To size installation surface **640** user **507** sets a first position indicator **711**, e.g., a cross hair marker, on one corner of installation surface **640** of roof **600**. User **507** sets a second indicator **707** on another corner of installation surface **640**. User **507** sets a third position **709** by placing a third indicator on another corner of surface **705**. First, second and third positions define a length and a width measurement of a rectangle representing dimensions of surface **640**. In that manner ^{1st} measurements **561** are provided to modeling unit **591** as illustrated in FIG. **5**.

In one embodiment of the invention, image scaling module **590** of modeling unit **591** receives the dimensions provided by GUI **560** for an image, for example, image **553**. Image scaling module **590** further receives image scale information corresponding to image **553** from an image metadata source **530**.

In some embodiments of the invention, image metadata is provided within the image information received from the image source, e.g. image source **509**. In that case image retrieval module **110** extracts the image metadata from the received image information. In other embodiments of the invention image metadata is provided a source other than image source **509**. In that case the metadata for respective images is provided to image scaling module **590**. In some

embodiments of the invention, information identifying an image corresponding to metadata and vice versa (as indicated in FIG. **5** at **563**) is included in the image information and the metadata information. In that case the identifying information is used by system **500** to determine corresponding metadata for each displayed image.

FIG. **8** illustrates a viewport **800** displaying a second image of the roof of house **600** illustrated in FIG. **6**. The second image is displayed at a second orientation **870** with respect to the 3D axis orientation **770** of the first image. User **507** interacts with second image **850** to set first, second and third positions in the second image. To set first, second and third positions, user **507** places an indicator, such as a cross hair marker, on corresponding corners **811**, **807** and **809** of surface **640** as displayed in the second image. Each corner of surface **640** displayed in viewport **800** corresponds to a respective corner of surface **640** displayed in viewport **700**. For example corner **711** displayed in viewport **700** corresponds to corner **811** displayed in viewport **800**.

As marked by user **507** first, second and third positions define a length and a width measurement of generally rectangular surface **640**. Each measurement is taken in the second image with respect to a different axial orientation of the corresponding measurement taken in the first image. In that manner 1^{st} and 2^{nd} length and width measurements **562** are provided to modeling unit **591** as illustrated in FIG. **5**.

In one embodiment of the invention described above, a translator unit **596** comprises a commercially available 3D modeling software package such as AutoCad™. When provided with points defining a shape in first and second orientations, translator unit **596** is configured to describe the shape in any orientation, for example a side elevation view orientation illustrated in FIG. **9**. In that manner translator unit **596** provides a measurement H (indicated at **625** of FIG. **9**) representing displacement of roof ridge **641** from roof base **635**.

Second Embodiment

Alternative embodiments of sizing subsystem **500** are illustrated in FIGS. **11-19**. FIG. **11** illustrates various example embodiments of an interactive measuring tool (**1150**, **1107**, and **1117**) for use in sizing surfaces such as roof of house **600** in FIG. **6**. In one embodiment of the invention at least one of tools **1150**, **1107** and **1117** are displayed in a viewport **110** to a user. A user selects a tool to use for measuring. User manipulation of a selected measuring tool positions the tool with respect to first and second images depicting the same surface, for example roof of house **600** in FIG. **6**. The measuring tool is rotatable and scalable by user **507** to align at least two sides of the tool an image of an object to be measured, for example a roof surface to be measured.

In one example embodiment of the invention, a user selects tool **1150** from viewport **1100**. In one embodiment dimensions of side **1187** and **1177** of interactive measuring tool **1150** are calibrated before displaying tool **1150** in viewport **1100**. For example, a scale of pixels to feet is determined for image of a roof of a house **600** based on metadata associated with the image of house **600**. Therefore, system **100** is enabled to provide ‘real world’ measurements for a roof surface by relating the known scale to the displayed tool sides.

The position of interactive measuring tool **1150** within viewport **1100** is adjustable by user interaction with tool **1150** via a mouse, keyboard, trackball or other input/output device. In addition, length of sides **1187** and **1177** are user adjustable. Referring now to FIG. **6**, in order to measure an installation surface area, such as a roof **640** area of house **600** in FIG. **6**, user **507** positions measuring tool **1150** over an image of roof **600** in alignment with a side of the image of roof **600**. User **507** adjusts the length of a tool side, for example side **1187**, of measuring tool **1150** to correspond in length to the length of a side of the image of roof **600**. Another side **1187** of measuring tool **1150** is aligned with a third side of the image of roof **600** and likewise adjusted in length to correspond to the length of corresponding side in the image.

A roof ridge **641** is marked by user **507** dragging a line tool along an image of ridge **641** within the perimeter of measuring tool **1150**. When the ridge line has been drawn, user **507** initiates a reading of dimensions of measuring tool **1150**. In addition, an orientation of measuring tool with respect to axes **670** (of FIG. **6**) is determined.

FIG. **12** illustrates an image **1215** representing a top plan view of a surface, or face of a 3D shape such as the roof of house **600** illustrated in FIG. **6**. According to one embodiment of the invention a viewport **1200** displays first image **1215** to user **507**. The imaged surface shape **1215** is defined by a length L (at **1230**), a base B (indicated at **1235**) and a ridge line **1241**. The surface shape **1215** is oriented in accordance with a reference plane, for example the x-y plane of reference axis **1211**. User **507** operates a mouse, trackball, keyboard or other input/output device coupled to user system **506** to interact with the image **1215** as described below.

To size surface **1215** user **507** superimposes sizing tool, in this example tool **1117** (illustrated in FIG. **11**) over at least a portion of image **1215**. In one embodiment of the invention two sided sizing tool **1117** is defined by sides **1127** and **1137**. User **507** adjusts the dimensions of at least one of the tool sides **1127** and **1137** using a keyboard, mouse, trackball or other input/output device. For example, the length of tool side **1137** is adjusted to match a corresponding side length, e.g., L at **1230** of image surface **1215**. In one embodiment of the invention user **507** adjusts a side width (e.g., at **1127** in FIG. **11**) of sizing tool **1117** to match the length B (at **1235**) of surface image **1215**. In that manner user **507** generates measurements which describe shape **1215** by length and base measurements. Further in some embodiments, information defining an orientation of shape **1215** with respect to a reference axis **1211** is generated by comparing orientation of adjusted tool **1107** to reference axis **1211**. The orientation information is provided to modeling unit **591**.

The image measurements comprising dimensions and orientation of measuring tool **1117**, as adjusted to image **1215** in viewport **1200**, are provided to modeling unit **591** as illustrated in FIG. **5**. Modeling unit **591** determines a transform that enables points defining the shape of measuring tool **1117**, as adjusted to image **1215** in a top down orientation of FIG. **11**, to be mapped to a projected shape of measuring tool **1117** as it would appear in any other orientation of tool **1117** in a 3D space. The transform enables subsequent adjustments of any portion of tool **1117** by a user to cause automatic corresponding adjustment of remaining portions of tool **1117** such that the aspect ratio of side **1127** to side **1137** of tool **1117** is preserved through subsequent measurements and movement of tool **1117**.

Having set the aspect ratio of tool **1117**, user **507** manipulates measuring tool **1117** to a second viewport **1300**, illustrated in FIG. **13**. FIG. **13** illustrates a viewport **1300** displaying a perspective image **1315** of roof of house **600** (illustrated in FIG. **6**). Perspective image **1315** of roof of house **600** is oriented with respect to a reference 3D axis **1311**. Viewport **1300** permits manipulation of tool **1117** in three dimensions, x, z and z, with respect to axis **1311**. User **507** adjusts tool **1117** with respect to the base B and length L of perspective image **1315** in three dimensions such that at least one of the

width or length of the sizing tool **1117** matches a corresponding one of base B and length L of image **1315**.

Manipulation of measuring tool **1117** in 3 dimensions (for example to align with B and L of **1315** in FIG. **13**) is enabled by transform/translation unit **596** of modeling unit **591**, illustrated in FIG. **5**. Adjustment of length of any side of measuring tool **1117** causes corresponding adjustment of length of remaining side of tool **1117**.

FIG. **15** illustrates an embodiment of measuring tool **1107** of FIG. **11** in 3 dimensions for alignment with roof image **600** in viewport **1300** illustrated in FIG. **13**. A ridge line is indicated in FIG. **15** at **641**

FIGS. **16-10** illustrate successive steps in manipulating measuring tool **1107** to obtain measurements of a roof image. For example, the steps indicate placement of measuring tool **1107** in viewport **1300** with respect to an image of roof **600** (illustrated in FIG. **6**). Once placed in an appropriate orientation, that is, in alignment with a side of the image, side lengths of tool **1117** are adjusted to conform to side lengths of roof of house **600**, as illustrated in FIG. **17**. Measuring tool **1107** is positioned in FIG. **17** such that side b of measuring tool **1107** aligns with base b of roof **600**. When measuring tool **1107** is positioned as illustrated in FIG. **17** 2^{nd} measurements are obtained of measuring tool **1107**. In addition information about orientation of measuring tool **1107** with respect to a reference axis **1611** is provided to modeling tool **1107**. Transform/translation unit **596** uses information thus provided, in addition to information provided by scaling unit **592**, to determine 'real world' measurements for roof **600**.

FIGS. **18** and **19** illustrate measuring tool **1107** as used to measure displacement of a ridge of roof **650** from base **635**. The displacement information is used by modeling unit **591** (FIG. **5**) to determine pitch of roof **600**. As illustrated in FIG. **18** user **507** displaces measuring tool **1107** in the z direction from its position illustrated in FIG. **17** to the position illustrated in FIG. **18**, i.e., displaced by a distance d from base **635** to ridge **641**. FIG. **19** illustrates a difference d between placement of measuring tool **1107** in FIG. **17** and placement of measuring tool **1107** in FIG. **18**. The difference measurement d is provided to modeling unit **591**. Transform translation unit **596** determines height h of ridge **641** with respect to base **635** of real world roof **600**. Once the real world height is known, pitch of the roof is determined.

The description provided above relates to one embodiment of measuring tool **1107**. An alternative embodiment of measuring tool **1107** is illustrated in FIG. **11** at **1117**. In the embodiment illustrated at **1117** of FIG. **11** only two sides of a measuring tool (one side representing width and one side representing length) are displayed to user **507**.

Returning now to FIG. **5**, 3D transformer/translation module **596** uses the displacement information to generate a 3D model of roof **600**. The model provides a description corresponding to a side elevation view of the same roof **600** including a height dimension d. An example side elevation description is illustrated in FIG. **9**.

In one embodiment of the invention scaling unit **592** translates viewport dimensions to real world dimensions. In one embodiment of the invention the real world dimensions are obtained from metadata. The system then tracks changes in the geometry of measuring tool **1107** in relation to the real world dimensions.

In some embodiments of the invention images displayed in a viewport are adjusted to conform to conventions. For example, in one embodiment of the invention images are scaled to ensure x pixels in a displayed image=x feet in a real world imaged object. In another example, an image orientation is adjusted such that a vertical direction (up down) in the real world imaged object corresponds to a selected reference axis, e.g., a Z axis for the image displayed in a viewport.

A simple implementation of installation surface measuring tool **1107** comprises a 2D rectangle with predetermined height and width (equivalent to a 3D box with height=0) overlaid over the image of an object with known magnification/scale/resolution (resolution) and rotation (e.g. 1 pixel=1 foot top-down image). The dimensions (height & width) of the first model can be adjusted to match the dimensions of the object. Since the resolution of the image is known, the real-world dimensions of the object can be calculated. (e.g. A length of 10 pixels on the image could represent 10 feet on the ground).

FIG. **28** illustrates steps of a method for determining pitch of an installation surface. a plan view of an image representing the installation surface is displayed at step **2803**. First indicia are positioned about a perimeter of the installation surface image at step **2805**. A perspective image of the installation surface is displayed at step **2807**. Second indicia are placed about the perimeter of the image of the installation surface. At step **2813** a sizing window is displaced vertically in the perspective to traverse the distance between the base of the installation surface and a ridge of the surface. The displacement is transformed to a height measurement, for example height corresponding to a side elevation view and representing real world height of a roof ridge. Pitch is calculated at step **2817** based on the height.

FIG. **20** Shading Subsystem

Photovoltaic cells' electrical output is extremely sensitive to shading. When even a small portion of a cell, module, or array is shaded, while the remainder is in sunlight, the output falls dramatically. Therefore embodiments of the invention provide systems and methods that consider shading factors such as trees, architectural features, flag poles, or other obstructions in provisioning a solar energy system.

FIG. **20** illustrates an embodiment of a sizing subsystem **500** configured to determine shading for an installation surface. To determine shading user **507** measures images of shading objects as they appear in viewports together with an installation surface. User **507** sizes shading objects in the same manner as described above for sizing a roof.

Various embodiments of the invention use a plurality of corresponding images (and associated meta-data, where available) of a single structure to determine shading factors. A technique of one embodiment of the invention maps real-world points in a 3d space to images of a structure. Reference shapes comprising two and/or three dimensional shapes are super-imposable onto one or more of these images in a manner similar to that described above for measurement tool **1107** of FIGS. **12-19**.

Measurements resulting from the superimposition are used by modeling unit **591** to calculate angles, distances, and relative positions of potential shading objects with respect to an installation surface. In one embodiment of the invention a user is enabled to create and/or manipulate basic shapes, such as measuring tool **1107**, to superimpose the basic shapes onto images of the structure obtained by mapping real-world points. In one embodiment of the invention real-world points are referenced to images obtained, for example, from a geographic or geologic database comprising two dimensional and/or three dimensional satellite images of structures such as residential structures.

According to some embodiments of the invention a 3D model of a shading object is constructed by user **507** indicating a first set of perimeter points in a first image of a shading object and indicating a second set of corresponding perimeter points in a second image of the same object. In other embodiments of the invention top-most points of shading objects are identified without indicating perimeter points. In some embodiments of the invention shading objects are created for

a scene using 3d primatives or meshes. In some embodiments shading objects are created using Computer Assisted Drawing (CAD) software.

In other embodiments shading objects are created automatically by turning multiple perimeter points from one-or-more viewports into a 3d object/mesh. Modeling unit **591**, including scaler **592** and 3D position transformer translator **596**, operate on the indicated points in the first and second images in the same manner as described with respect to indicators for installation surfaces. Modeling unit **591** provides a scene model comprising three dimensional descriptions of an installation surface as well as user selected shading objects in the vicinity of the installation surface. A shadow projection calculator receives the scene model from modeling unit **591**.

In addition shadow projection calculator receives a sun ray model form sun path model **2005**. In one embodiment of the invention sun path model **2005** comprises a database of sun ray projections by latitude and longitude and by month, year, day and time of day. In one embodiment of the invention boundaries of shadows cast by shading objects on the installation surface are determined by projecting the outline of the shading object onto the installation surface, the lines of projection being parallel to the sun's rays. The direction of the sun's rays relative to the installation surface is determined by comparing the sun ray model to the scene model.

Sun path model **2005** is based upon charts or sun calculators that have been prepared by different organizations. One example of widely available solar diagrams is the Sun Angle Calculator, which is available from the Libby-Owens-Ford Glass Company in the United States. This is a slide rule type of device that will indicate directly the value of H.S.A. and V.S.A. for any time and date during the year at all the latitudes evenly divisible by four between 24 and 52 degrees. The calculator can also be used to estimate the solar irradiation that any sunlit surface can receive on a clear day at any season. Another suitable set of charts is the Diagrammes Solaires prepared by the Centre Scientifique et Technique du Bâtiment in France. These charts and an accompanying brochure on how to use them (in French) are available through the Division of Building Research of the National Research Council of Canada or directly from C.S.T.B. in Paris. These are suitable to construct the H.S.A. and V.S.A. for any combination of time, date, latitude and wall orientation.

The position of shadows on the installation surface is determined by reference to scene model **2009**. The scene model is oriented in a reference orientation and rotated in a 3D space to simulate the daily rotation of the earth. In that manner scene model **2009** and sun ray model **2007** are configured to simulate a conventional heliodon. A heliodon is a special turntable that causes a physical scene model to move with respect to a reference light source as the real world scene will move with respect to the sun. The model adjustable for latitude and date. The orientation of the installation surface is taken into account when initiating the model rotation.

Table 1 provides an example shadow calculation useful for implementing embodiments of shadow projection calculator **2000**.

TABLE I

Length of Projection in Feet Required to Cast A Shadow 1 Foot High on a Building at 44° North Latitude

Time (Sundial Time)	South: 21 May 21 Jul.	South: 21 Mar. 21 Sep.	30° East of South: 21 May 21 Jul.	30° East of South: 21 Mar. 21 Sep.	60° East of South: 21 May 21 Jul.	60° East of South: 21 Mar. 21 Sep.	East: 21 May 21 Jul.	East: 21 Mar. 21 Sep.
8	0.14	0.97	0.83	2.04	1.29	2.56	1.41	2.40
9	0.30	0.97	0.73	1.53	0.95	1.68	0.93	1.39
10	0.39	0.97	0.62	1.24	0.69	1.18	0.57	0.80
11	0.43	0.97	0.51	1.02	0.45	0.81	0.27	0.37
12	0.45	0.97	0.39	0.84	0.22	0.48	—	—
13	0.43	0.97	0.24	0.65	—	0.16	—	—
14	0.39	0.97	0.05	0.44	—	—	—	—
15	0.30	0.97	—	0.14	—	—	—	—
16	0.14	0.97	—	—	—	—	—	—

In addition a variety of graphics programs for visualizing solar shading for proposed building are commercially available and suitable for use in constructing various embodiments of the invention. For example "Visual Sun Chart" is a graphics program useful to determine if access to solar energy for an installation surface.

According to an embodiment of a method of the invention, images are analyzed to determine if there are any objects shading a proposed system at greater than a given angle above the horizon. For example in one embodiment of the invention images are analyzed to determine if there are any objects shading a proposed system at angles between about 5 degrees and 50 degrees between stated points on the azimuth. In another embodiment of the invention images are analyzed to determine if there are any objects shading a proposed system at greater than about a 26 degree angle between stated points on the azimuth.

The shading information thus obtained is used in one embodiment of the invention to determine the level of rebate applicable to a proposed system at that site. In contrast to systems of the invention, conventional systems perform this step manually by a costly on-site visit. A technician uses a tool that measures the geometric angles of objects located in the viewfinder of the tool, facing away from the system to determine shading impact. The techniques of some embodiments of the invention obviate the necessity of such an on-site visit.

Sun Path Model **2005**

Table is an example of data comprising sun path model **2005**.

Time (solar)	Mar. 21 and Sep. 21		Jun. 21		Dec. 21	
	$\square_s$	$\square_s$	$\square_s$	$\square_s$	$\square_s$	$\square_s$
06.00	0.0	−89.6	5.4	−247.1	0.0	−67.2
08.00	29.0	−81.8	32.7	−250.7	20.6	−58.1
10.00	57.1	−67.0	60.0	−246.6	42.7	−38.6

-continued

Time (solar)	Mar. 21 and Sep. 21		Jun. 21		Dec. 21	
$\square_s$	$\square_s$	$\square_s$	$\square_s$	$\square_s$	$\square_s$	$\square_s$
12.00	75.9	0.0	80.3	−180.0	52.9	0.0
14.00	57.1	67.0	60.0	−113.4	42.7	38.6
16.00	29.0	81.8	32.7	−109.3	20.6	58.1
18.00	0.0	89.6	5.4	−112.9	0.0	67.2

The sun-path model **2005** is a plot of the angular position of the sun as it traverses the sky on a given day. In such a model, the horizontal axis shows the azimuth angle, and the vertical axis shows the altitude angle.

Solar time is the time based on the physical angular motion of the sun. Solar noon is the time when the altitude angle of the sun reaches its peak. Solar time can be calculated from

$$t_s=t_l\_4(L_{gs}-L_{gl})+E_{qt}$$

where

t_s=solar time,

t_l=local standard time,

L_{gs}=standard local longitude,

L_{gl}=actual longitude, and

E_{qt}=equation of time (min).

FIG. **29** illustrates steps of a method for determining shading for an installation surface. At step **2903** an image of the installation surface is received. At step **2905** dimensions of the surface are determined by measuring the surface as it appears in the image. At step **2907** shading objects appearing in the image are measured. At step **2909** a scene model is generated based on the measurements of the surface and the shading objects. At step **2911** sun path data is obtained. At step **2913** the sun path data is used to determine sun ray projection onto the scene model. At step **2915** shading for the surface is determined based on the sun ray projection.

Panel Orientation

One embodiment of the invention accounts for panel orientation in determining sun access of an installation surface. In one embodiment of the invention a solar panel array is mounted at a fixed angle from the horizontal. In other embodiments of the invention a solar panel array is mounted on a sun-tracking mechanism. According to one embodiment of the invention sizing subsystem **500** of a system of the invention is configured to communicate with a source of solar data, for example sun path model **2005**. In one embodiment of the invention the source of solar data comprises average high and lows for panels oriented at the same angle as the latitude of major US cities. Sizing module **500** determines a recommended orientation for solar panels based at least in part on the information obtained from the source of solar data **2005**.

In one embodiment of the invention a solar panel array is mounted on an installation surface at a fixed angle from the horizontal. In other embodiments of the invention a solar panel array is mounted on a sun-tracking mechanism.

FIG. **23** Generating Energy System Specifications

One example embodiment of the invention generates energy system specifications customized for a user selected installation site. Energy system specifications relate to energy generating capacity of a selected site. For example for installation of a solar energy system, a roof surface is evaluated to determine energy related parameters, such as available installation area, orientation of the installation surface with respect to the sun, and the effects of shading objects on the installation surface. A total maximum energy generating capacity of the roof is determined based on the parameters and based on the energy generating characteristics of available solar system components.

FIG. **23** is a block diagram of an energy system specification (ESS) generator **2300** according to an embodiment of the invention. ESS generator **300** receives surface dimension information related to a site at input **381**. In one embodiment of the invention input **381** is provided with sizing information, for example, from sizing subsystem **200**. Sizing information can include, for example, surface area available for installation, shape of the available area, slope of the area, and other information related to the installation site.

ESS generator **2300** provides energy system specifications for a site based on the surface dimension information for the site. Energy system specifications comprise information for determining suitable energy system components for installation on a site to be provisioned. For an example site comprising a rooftop, ESS generator determine energy per square foot of roof surface.

In one embodiment of the invention, ESS generator determines an amount of energy which is potentially generated by each installable surface area of an installation site. In one example embodiment, energy potentially generated is given by:

Surface Area×Solar Insulation×Energy reduction due to pitch & azimuth=Potential Solar Energy.

Wherein surface area is an amount of surface area in square meters (or equivalent) and solar Insulation is the amount of solar energy radiation received, typically measured as "kilowatt hours per year per kilowatt peak rating".

In one embodiment of the invention solar insulation is calculated based on data in a solar insulation database (not shown). In that embodiment user-provided location information is used to search the insulation database for a solar insulation data associated with the site selected for installation. The insulation calculations are carried out in one embodiment of the invention using the energy system specifications generated by energy system specification subsystem **2300** to correspond to installation surface dimensions provided by sizing subsystem **200**. In other embodiments of the invention energy system specification subsystem **2300** calculates insulation based on local electric costs determined by reference to a database such as database **117** (illustrated in FIG. **1**).

In one embodiment of the invention ESS generator **2300** provides specifications for a site based on site's latitude and longitude. In one embodiment of the invention the calculation accounts for pitch & azimuth information received from sizing subsystem **200**. As used herein the term 'azimuth' refers to an angle with respect to north. In some practical implementations of energy systems, energy output of an installed energy system is reduced due to pitch & azimuth considerations.

In one embodiment of the invention a combination of tilt of a slope compared to "flat" and the azimuth of the slope is determined by system **2400** based on information provided by sizing subsystem **200**. The energy received by a surface is reduced by this determination. An amount of the reduction amount is calculated automatically in one embodiment of the invention.

In another embodiment of the invention the reduction amount is calculated by reference to a suitable database containing standard reference tables. In one embodiment of the invention ESS generator **2300** identifies a model site with characteristics similar to the site under evaluation by ESS generator **2300**. A dataset for the model site is adjusted to

match as closely as possible the characteristics of the site under consideration by ESS generator **2300**. For example, if a site under consideration by ESS generator **2300** is twice as big as a model site and at the same tilt & azimuth, then ESS generator **2300** multiplies the Energy System Specification parameter "energy output" by 2 for the site under consideration. In one embodiment of the invention ESS generator **2300** is provided with shading information from a shading subsystem **500**. Shading information is provided for the surface for which specifications are to be generated. Shading effects are expressed as energy per square foot of surface area in one embodiment of the invention.

In some embodiments of the invention ESS subsystem **2300** receives information about home energy consumption related to the consumer's residence from a source of residential energy consumption, for example database **117** illustrated in FIG. **1**. ESS generator **2300** adjusts an energy system specification based on the home energy consumption information. For example, if home energy consumption is lower than the potentially generated energy, the system specifications may be adjusted such that a system with a lower than maximum possible energy output is defined.

One embodiment of the invention provides for automatic selection of energy system components based on energy system specifications provided by ESS generator **2300**. For example, specifications for energy system components are stored in a component database **2305**. ESS generator **2300** is configured to communicate with component database **2305**. ESS generator **300** compares energy system specifications stored in the database with specifications for energy system components for a site.

FIG. **25** is a flowchart illustrating steps of a method for generating energy system specifications according to an embodiment of the invention. At step **2501** an image including a surface upon which an energy system is to be installed is received. At step **2503** pitch of the installation surface is determined by measuring the surface as it appears in the image. At step **2505** dimensions of the installation surface are determined by measuring the surface as it appears in the image. At step **2507** compass orientation of the installation surface is determined. In one embodiment of the invention compass orientation is determined by analyzing the image of the surface. In other embodiments of the invention compass orientation is determined using metadata associated with the image.

In an optional step **2509**, shading information for the installation surface is calculated based on the image of the surface including shading objects impacting the installation surface. Maximum energy generating capacity of the installation surface is determined by accounting for the pitch, surface dimensions, surface orientation and shading in determining insulation of the surface. In some embodiments of the invention energy generating capacity is calculated considering energy generating capacity of selected energy system components. In one embodiment of the invention energy generating capacity is expressed as KW per square foot.

Components

FIG. **24** illustrates an example solar energy system **2400** including typical components. Information about the components of energy system **2400** are stored in component database **2305** of subsystem **2300**. System **2400** comprises an array **2450** of solar panels **2401-2409**. Panels **2401-2409** are connected through a DC disconnect **2411** to an inverter **2413**. Inverter **2413** is connected through a meter **2414** to an AC disconnect component **2415**. AC disconnect component **2415** is connected to an AC service Entrance **2417**. AC service entrance **2417** is connected through utility meter **2419** to a conventional energy grid.

Table 1 provides example specification information for components, for example, commercially available solar system panels.

TABLE 1

Model	XW6048-120/240-60	XW4548-120/240-60	XW4024-120/240-60
Part Number	705200	705201	705202
Price	$4500.00	$3950.00	$3950.00
Output Power (Watts)	6000	4500	4000
Surge rating (10 seconds)	12000	9000	8000
Efficiency - Low Load		95%	
Efficiency - CEC weighted	92.5%	93%	91%
CEC power rating	5752 W	4500 W	4000 W
DC Current at rated power	130 A	96 A	178 A

FIG. **24** Quoting System

FIG. **24** illustrates a quoting subsystem **2400** according to an embodiment of the invention. Quoting subsystem **2400** comprises a user interface module **2460** configured for communication with a computer system **2406** of a user **2407**. In some embodiments of the invention user **2407** is a potential purchaser of an energy system. For example user **2407** is a homeowner interested in purchasing a solar energy system for installation on a roof of a home. In other embodiments of the invention, user **2407** is third party provider of solar energy systems. In that case user **2407** interacts with quoting system **2400** to provide quotes to, for example, commercial enterprises, government agencies and other parties interested in procuring a solar energy system for installation on a site. User interface module **2460** is coupled to a package analysis module **2487**, a package manager unit **2488**, and a package view unit **2486**.

In one embodiment of the invention a visual image of the customer's roof is displayed along with a pre-determined system of an average size. A consumer is then enabled to 'drag and drop' solar panels, and in some embodiments other components, on and off of the displayed image. Some embodiments of the invention enable a consumer to scale the system up and down in size using a mouse, keyboard or other input device. Such embodiments enable consumers to increase and decrease the size of the system to suit the consumer's aesthetic and economic preferences. Some embodiments of the invention automatically adjust in real-time the on-screen display of the package information including cost, economic and environmental outputs in accordance with each 'drag and drop' adjustment.

In that manner embodiments of the invention enable a consumer to engineer a custom solar system remotely. An energy specification subsystem **300** is coupled to package analysis module **2487** and to an image analyzer system **2490**. Image analyzer system **2490** is coupled to a source **2409** of images **2453**, **2454**. A model storage unit **2491** is coupled to package analyzer **2487**. Model storage unit **2491** stores reference packages comprising, for example, packages comprising a variety of predetermined package configurations including commonly used component sizes.

Package analyzer **2487** is coupled to an energy components database **2405**. Energy components database **2405** stores specifications, including cost of energy system components. An example energy system component specification is illustrated at **2493**. Package information comprising information related to components selected to comprise a package is provided from energy components database **2405** to package

manager unit **2488**. Package manager unit **2488** stores package information in a package information storage unit **2497**. According to one embodiment of the invention package information storage unit **2497** stores images and package information related to package components. Package view unit **2487** provides images of assembled packages for display as purchase options on display device **2408** of system **2406** to user **2407**.

As illustrated in FIG. **22** systems and methods of the invention provide a displayed image **2503** of a customer engineered solar PV system **2450** as the system appears on the customer's roof **600**. In one embodiment of the invention, user selectable packages **2501** are displayed with the image of the customer's roof. Selection of a package option will cause the displayed image of the customer's roof to change the solar PV system image to correspond to a selected package.

In one embodiment of the invention a quote for the displayed system is provided in association with the image of the system. According to some embodiments of the inventions the system also displays economics and environmental information about a selected package option. Economic and environmental information include such factors as: energy produced, cost of the system and rebate, electricity cost reduction, payback period, CO2 tons avoided, etc. In one embodiment of the invention economic and environmental information is displayed on-screen with the selectable package configurations illustrated at **2501** in FIG. **23**. Embodiments of the invention are configured to communicate with databases, for example databases of third-party data providers, comprising electricity data, solar output data, geographic photographic data, and subsidy data. Accordingly the invention provides a comprehensive online solution for consumers interested in investigating the benefits of a solar PV system.

In one embodiment of the invention, user interface module **2460** of system **2400** illustrated in FIG. **24** communicates with user system **2406** via a communications link such as the Internet to receive user provided information. The user provided information includes a location of a site to be provisioned with an energy system. The location information is provided to a package analyzer **2487**. Also provided to package analyzer **2487** is an energy system specification for the site at the location provided by user **2407**.

In some embodiments of the invention sizing subsystem **200** (illustrated in FIG. **5** at **500**) receives energy consumption data related to the user specified location, from a source of energy consumption data **117**. According to some embodiments of the invention sizing module **200** receives user provided system criteria information from user system **106**, for example, a percentage of total energy user **2407** desires to supply using a solar energy system. Based on the information about energy consumption received from database **117** and the desired energy production of a solar energy system as indicated by user **2407**, and further on the energy specification provided by energy specification subsystem **300**, package analyzer **2487** determines at least one package comprising components matching the criteria as closely as possible.

FIG. **26** illustrates steps of a method for quoting energy systems according to an embodiment of the invention. At step **2601** site dimensions are received, for example, from a sizing subsystem such as subsystem **500** illustrated in FIG. **1**. At step **2611** energy specifications are generated for the site based on the site dimensions. The specifications are generated, for example, by an energy system specification generator such as generator **2300** illustrated in FIG. **24**. At step **2613** components are automatically selected from a component database based on the site dimensions and the energy system specifications. In cases where a plurality of possible component configurations are suitable for meeting an energy system specification, a plurality of package options comprising various arrangements of suitable energy system components are determined. The package options are displayed on a display device of potential system buyer at step **2621**.

At step **2623** a package selection is received from a potential system buyer indicating one of the plurality of displayed packages. Once a package selection is received systems and methods of the invention display information about the selected package including, for example, cost and energy savings. In one embodiment of the invention the step of obtaining site dimensions at **2601** is carried out by receiving information about the site location at step **2603**. At step **2605** an image is selected, for example, from a source of geographical images. The selected image is analyzed at step **2607** to determine site dimensions.

According to one embodiment of the invention the step **2613** of selecting components to comprise a package is carried out by calculating component sizes based on system specifications at step **2615**. Packages are configured based on the calculated component sizes at step **2617**. The packages are displayed to a customer at step **2619**.

A package manager unit **2488** receives package information from package analysis unit **2487** and stores the information in package information storage **2497**. Package manager unit **2488** receives package selection and other information from user **2407** via GUI **2460**. In one embodiment of the invention package manager unit **2488** provides package views to a user **2407** while enabling user **2407** to interact with package manager **2497** to customize a system to the user's preferences.

In one embodiment of the invention economic and environmental information is provided to a display screen, **2408** of user system **2406**. The information is displayed in a first portion of display screen **2408** while information related to suitable packages is displayed in a second portion of display screen **2408**.

Embodiments of the invention are configured to communicate with databases, for example databases of third-party data providers, comprising electricity data, solar output data, geographic photographic data, and subsidy data. Accordingly the invention provides a comprehensive online solution for users to investigate the benefits of an energy system.

One embodiment of the invention remotely determines the feasibility of installing a solar energy system as a preliminary step to configuring a package. One embodiment of the invention automatically considers site access and other engineering issues in assessing feasibility. One embodiment of the invention remotely determines the presence of shading objects above a given angel of incidence and accounts for these objects in determining feasibility and in selecting package components. One embodiment of the invention automatically selects the optimal roof and roof portions upon which to locate PV panels for optimal photovoltaic performance. One embodiment of the invention determines a maximum system size that can be configured to fit on an optimal roof area.

FIG. **30** illustrates steps of a method for providing a quote to a potentially purchaser of an energy system according to one embodiment of the invention. at step **3101** candidate structures are selected for installation of solar energy system packages. for each candidate structure energy usage data is determined at step **3103**. For each candidate structure an image of the structure is obtained at step **3101**. Also for each structure, rebate information is obtained at step **3105**.

At step **3109** the images are analyzed to determine structure dimensions such as surface area and pitch. The dimensions are used in calculating the size of components to com-

prise an energy system for the structure. At step **3119** a system is offered to a customer for a candidate structure. In one embodiment of the invention a system offer is displayed on a display device for viewing by a customer. A selectable icon is provided enabling the customer to select the displayed offer for purchase at **3117**. In one embodiment of the invention the customer is contacted to offer the system for a candidate structure at an automatically determined price.

In one embodiment of the invention the displayed offer includes information about the offered system package or packages. Information is selected from a variety of information types, for example, information may include indications of a cost of a package and indications of energy savings expected to be realized by a particular offer.

Alternative Sizing Example

FIG. **31**

FIG. **31** illustrates an embodiment of the roof sizing **1107** tool described above with respect to FIGS. **15**-**19**. FIG. **31** is a top plan view of a roof **3110** of a structure **5** (not visible) as the structure appears displayed on a display screen of a computer system according to an embodiment of the invention. In the example shown, the roof **3110** is to be sized for installation of solar panels. The roof **3110** is defined by four lateral side edges **3112**, **3114**, **3116** and **3118**, and a ridge **3120**. According to one embodiment of the invention structure **5** is one of a plurality of structures within a single geographic region or example, a plurality of homes within a block or neighborhood. In one embodiment of the invention the top view image is obtained by downloading the image from a geophysical information service (GIS) such as provided by Microsoft, Google, or any of a number of other commercially available databases.

FIG. **32**

FIG. **32** illustrates a graphical user interface (GUI) for sizing the roof illustrated in FIG. **31**. The sizing GUI includes first, second, third and fourth reference lines. The first, second, third and fourth reference lines are displayed on a display device. The display device is operably coupled to a processor such as a personal computer programmed to enable a computer user to move the first, second third and fourth reference lines using a mouse, trackball or other positioning device.

In operation the user positions the first, second, third and fourth reference lines such that each reference line aligns with a corresponding lateral side edge **3112**, **3114**, **3116** and **3118**. In that manner a rectangle representing the shape of the roof to be sized is defined by the intersection of the reference lines. A first ridge reference line is positioned by the user to align with a ridge **20** of the roof to be sized. The rectangle and the first ridge reference line comprise a model **31100** of the roof to be sized. The model is saved and applied to different images of the same roof as part of a sizing method of an embodiment of the invention.

FIG. **33**

FIG. **33** illustrates model **31100** comprising four sides S**1**-S**4** and a first ridge R**1**. Arrows **6** and **7** indicate translation and rotation of the model in accordance with an embodiment of the invention. In other words, the invention enables a user to manipulate the model by translation and rotation while preserving the geometric relationship between the sides and ridge. For example side s**2** has a length dimension x whose value is retained during any translation or rotation of the model by a user. The model is represented in two dimensions and thus serves as a "base" reference during the sizing process.

FIG. **34**

FIG. **34** illustrates a perspective view, i.e., an oblique view, of a structure **5** including the roof illustrated in FIGS. **32**-**33** above. The model **31100** is rotatable and translatable by the user operating model interface controls (example illustrated in FIG. **36**). A user manipulates model **31100** to align at least two side edges of the model with at least two corresponding lateral sides of the roof structure. When the model is aligned a second ridge R**2** is defined aligning a reference line with the 2^{nd} reference ridge as illustrated in FIG. **34**. The separation of the first and second ridges after aligning the model to the roof is represented by h in FIG. **34**.

Thus, by positioning the model with respect to the perspective view of the roof, the user is able to determine the height of the ridge above the baseline of the roof. The length of a side perpendicular to the ridge line, for example side s**2**, is known from the previous step of generating the model by forming a rectangle using reference lines. Since the height and span (for example, length of side s**2**) of the roof are known, the roof pitch can be automatically calculated.

FIG. **35**

FIG. **35** illustrates a top plan view of a roof to be sized as the roof appears in an image obtained from a geographical information service (GIS). In one embodiment of the invention the image file obtained from the GIS is adapted to include information about the scale of the image. In one embodiment of the invention image metadata is transmitted with the image. The image metadata includes scale information for the image. In another embodiment of the invention the image file is adapted to include information about the exterior orientation of the camera capturing the image, and defines its location in space and its view direction. In another embodiment of the invention, the inner orientation defines the geometric parameters of the imaging process. This is primarily the focal length of the lens, but can also include the description of lens distortions. Further additional observations play an important role: With scale bars, basically a known distance of two points in space, or known fix points, the connection to the basic measuring units is created. FIG. **35** further illustrates first, second third and fourth reference lines as well as vertical reference lines as they appear comprising a graphical user interface according to an embodiment of the invention.

FIG. **36**

FIG. **36** is an image providing a perspective view of the roof of the image of FIG. **35** and illustrating vertical reference lines in accordance with an embodiment of the invention.

FIG. **37**

FIG. **37** is a second perspective view of the roof illustrated in FIGS. **35** and **36**. According to some embodiments of the invention a plurality of different perspective views are obtained. A model obtained using a top plan view is used on each perspective view to size the roof. The greater the number of perspective views used to obtain roof pitch information, the more accurate the resulting measurement of roof pitch.

There have thus been provided new and improved methods and systems for provisioning a solar energy system. While the invention has been shown and described with respect to particular embodiments, it is not thus limited. Numerous modifications, changes and enhancements will now be apparent to the reader. All of these variations remain within the spirit and scope of the invention.

We claim:

1. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

receive a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building;

correlate the first aerial image with the second aerial image;

generate, based at least in part on the correlation between the first and second aerial images, a three-dimensional

model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

generate and transmit a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical values that indicate the corresponding slope, area, and length of edges of at least some of the plurality of planar roof sections.

2. The computing system of claim **1** wherein the roof estimation module is further configured to correlate the first and second aerial images by receiving an indication of one or more corresponding points on the building shown in each of the first and second aerial images.

3. A system for remotely determining measurements of a roof, comprising: a computer including an input means, a display means and a non-transitory memory; and a roof estimation software program stored in the non-transitory memory and operable to cause a processor of the computer to: receive location information of a building in a selected region; receive image files representing a plurality of distinct roof sections of a roof of said building; determine, measurements of the roof including size, dimensions, and pitch of the plurality of distinct roof sections of the roof of said building based solely on the received image files; and outputting a report having the determined measurements therein.

4. A method for remotely determining measurements of a roof comprising:

receiving image files of at least a portion of a roof;

determining, by a computer system, roof pitch measurements by constructing a three-dimensional geometry of the roof based solely on the received image files;

determining roof pitch measurements based on the three dimensional geometry;

and providing a roof report based on the roof pitch measurements.

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